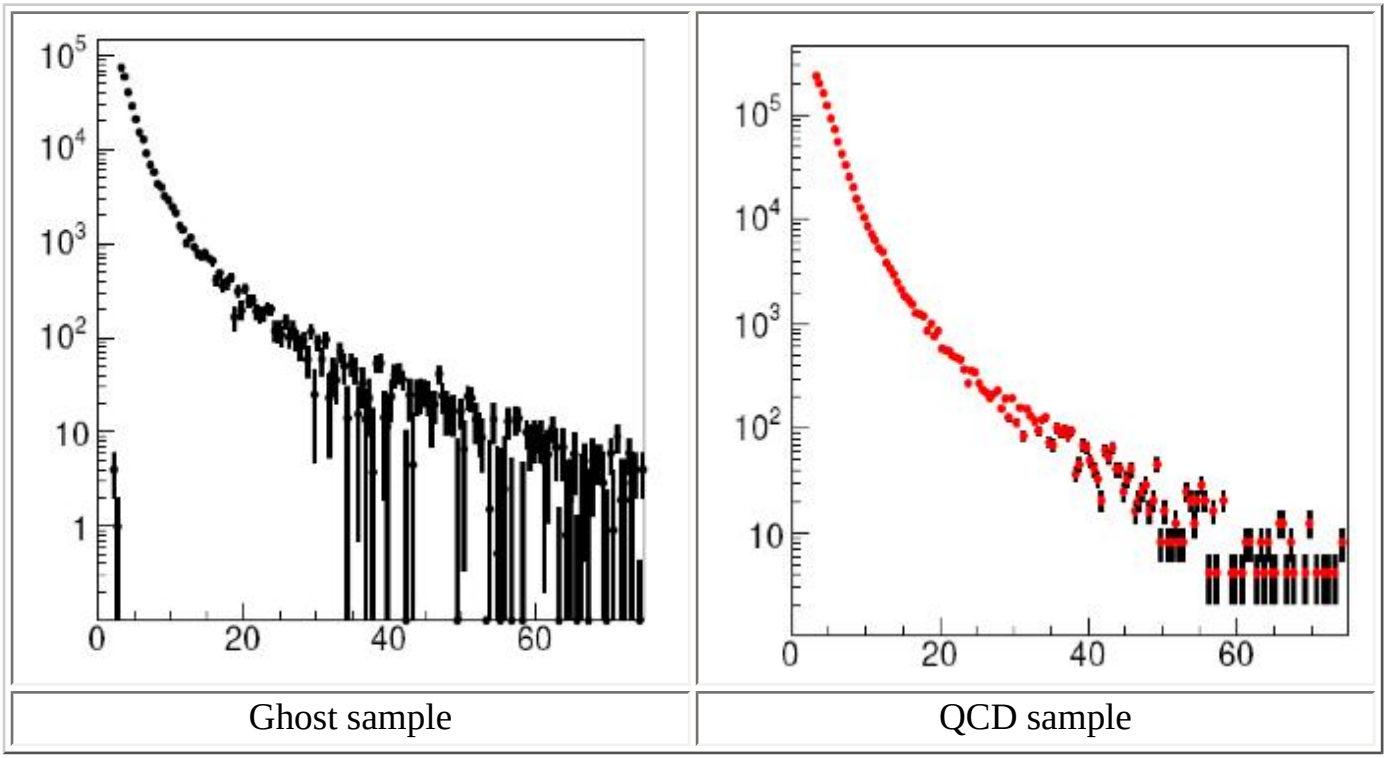
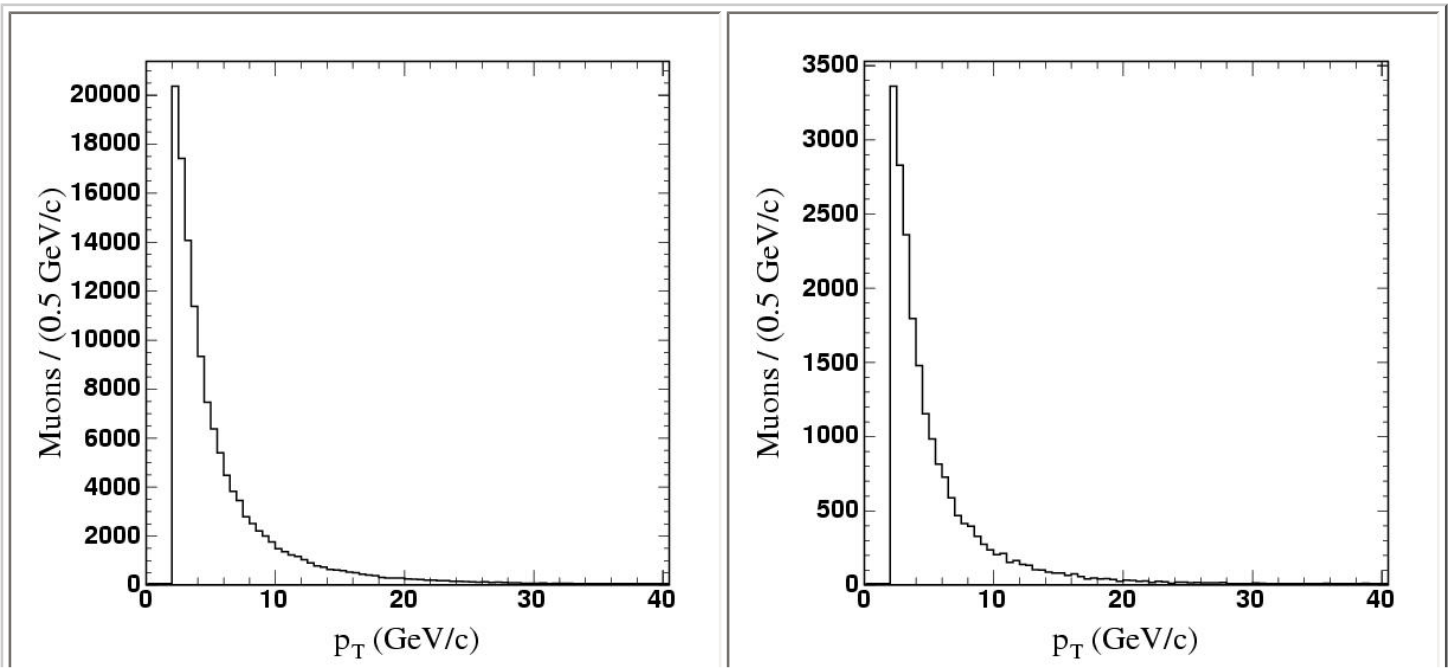
Plots related to muon properties

The following plots contain distributions of some basic properties of the initial muons and the additional muons found in the events.

1. P_T distribution of initial muons

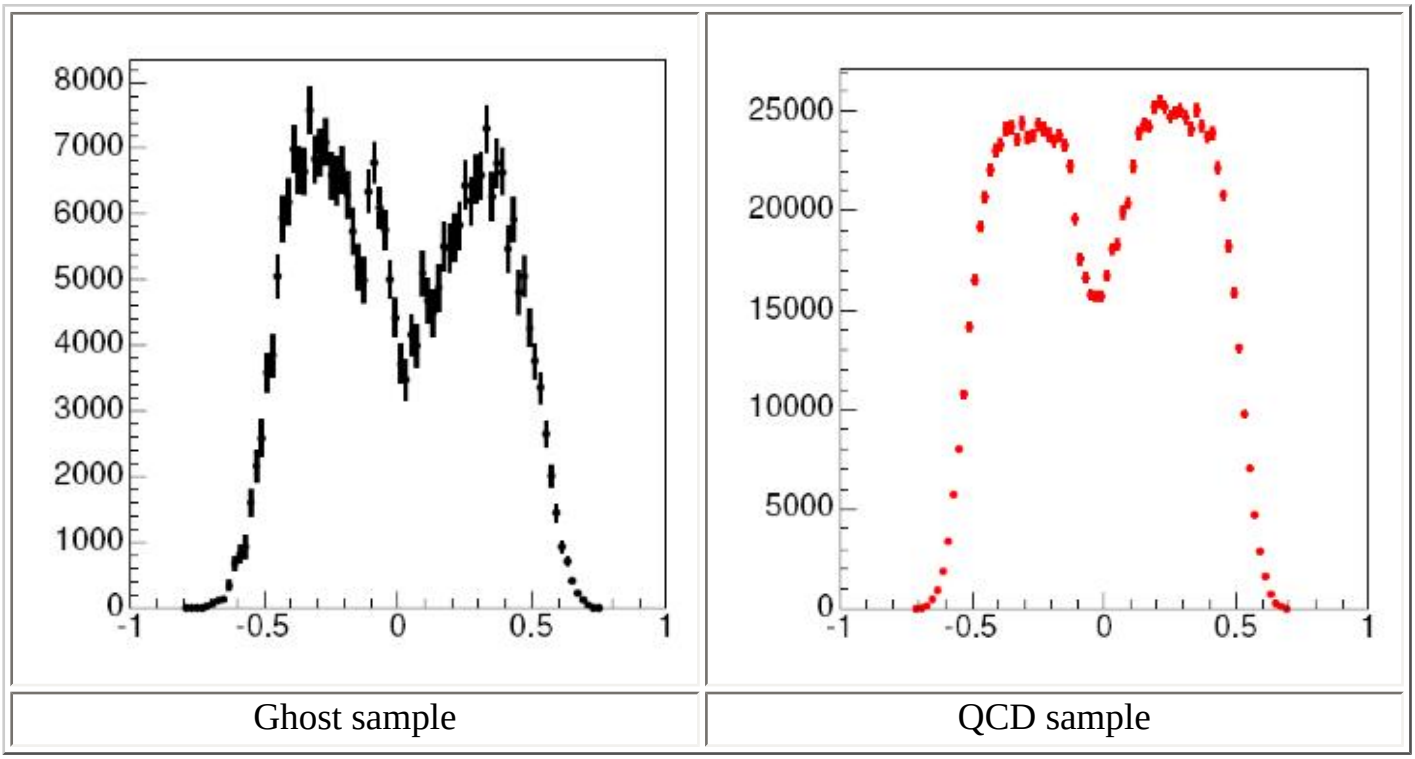


2. P_T distribution of additional muons



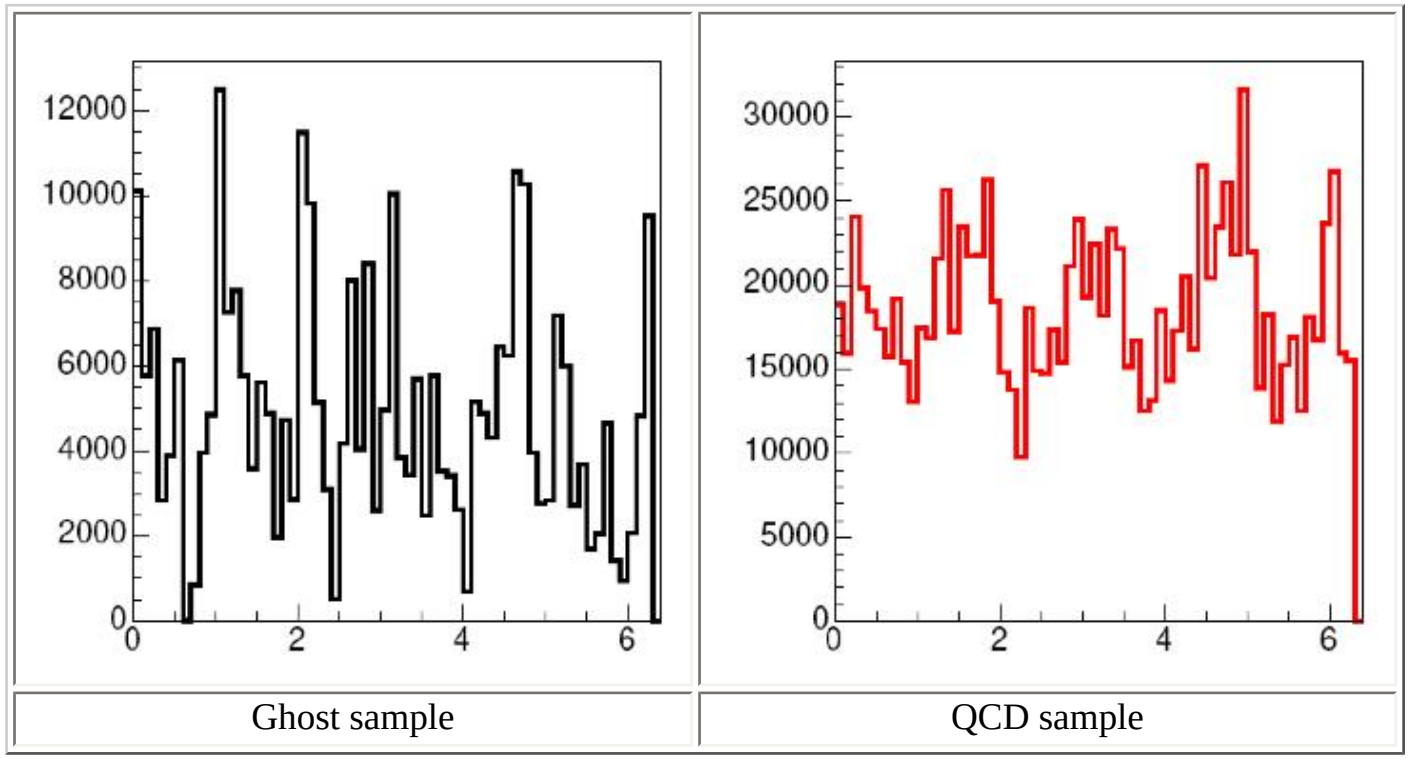
All events	QCD sample

3. η distribution of initial muons. Note that the spikey shape of both the η and φ distributions (next plot) in ghost events is an artifact of the inefficiency of the SVX+L00 detectors.



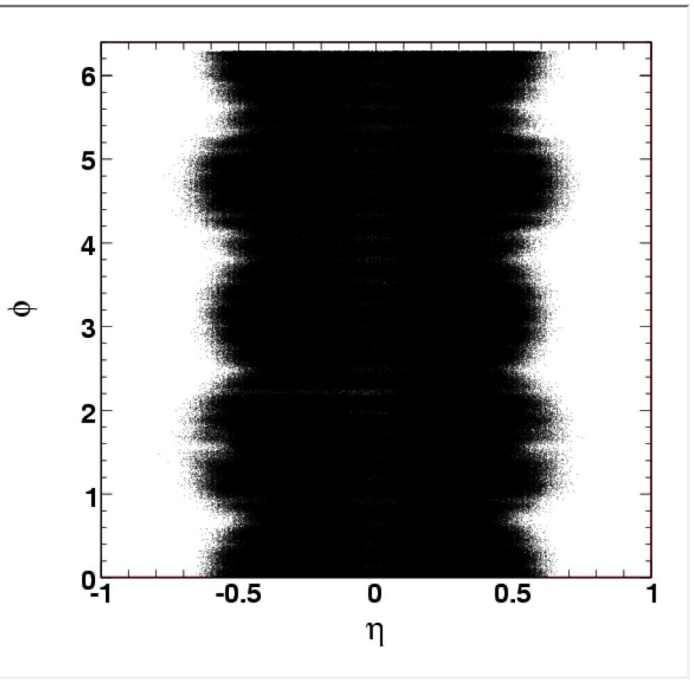
Ghost sample	QCD sample

4. φ distribution of initial muons

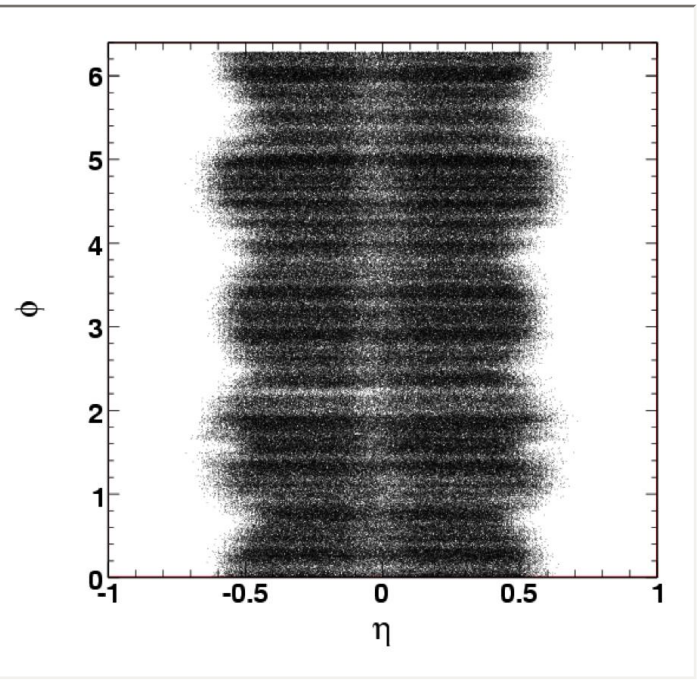


Ghost sample	QCD sample

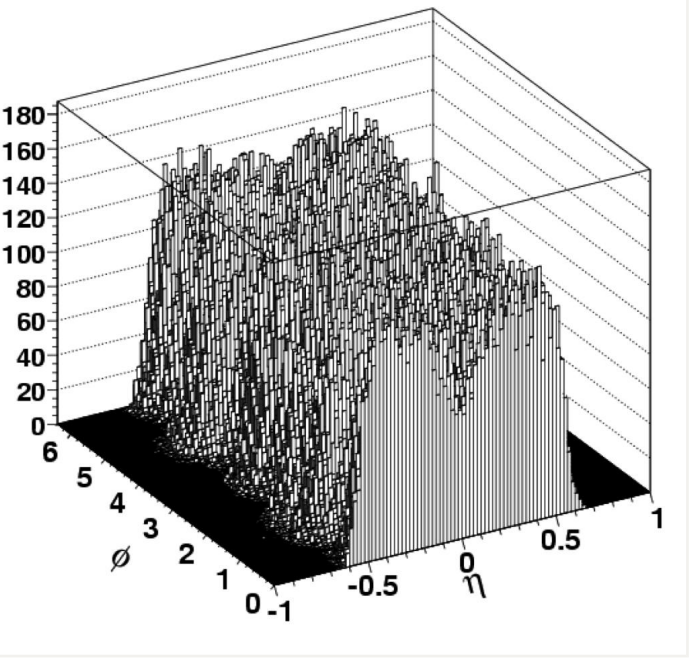
5. φ vs η distribution of initial muons



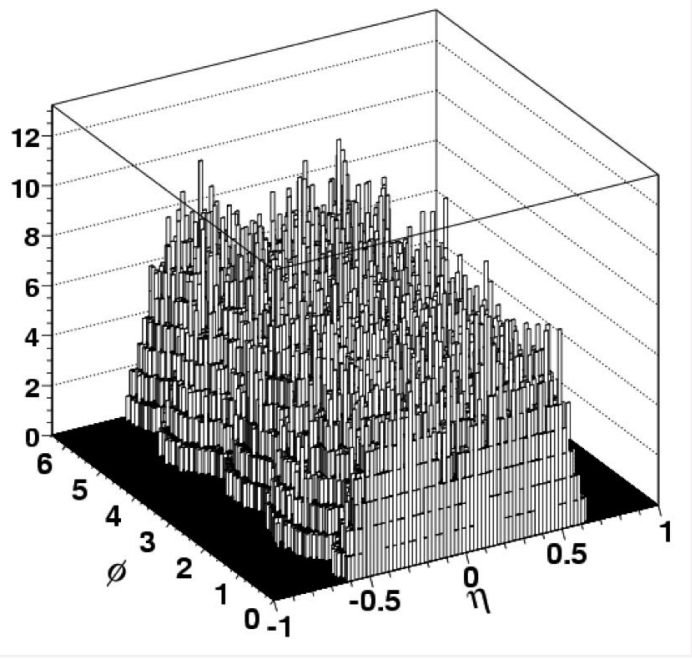
All muons



Tight SVX

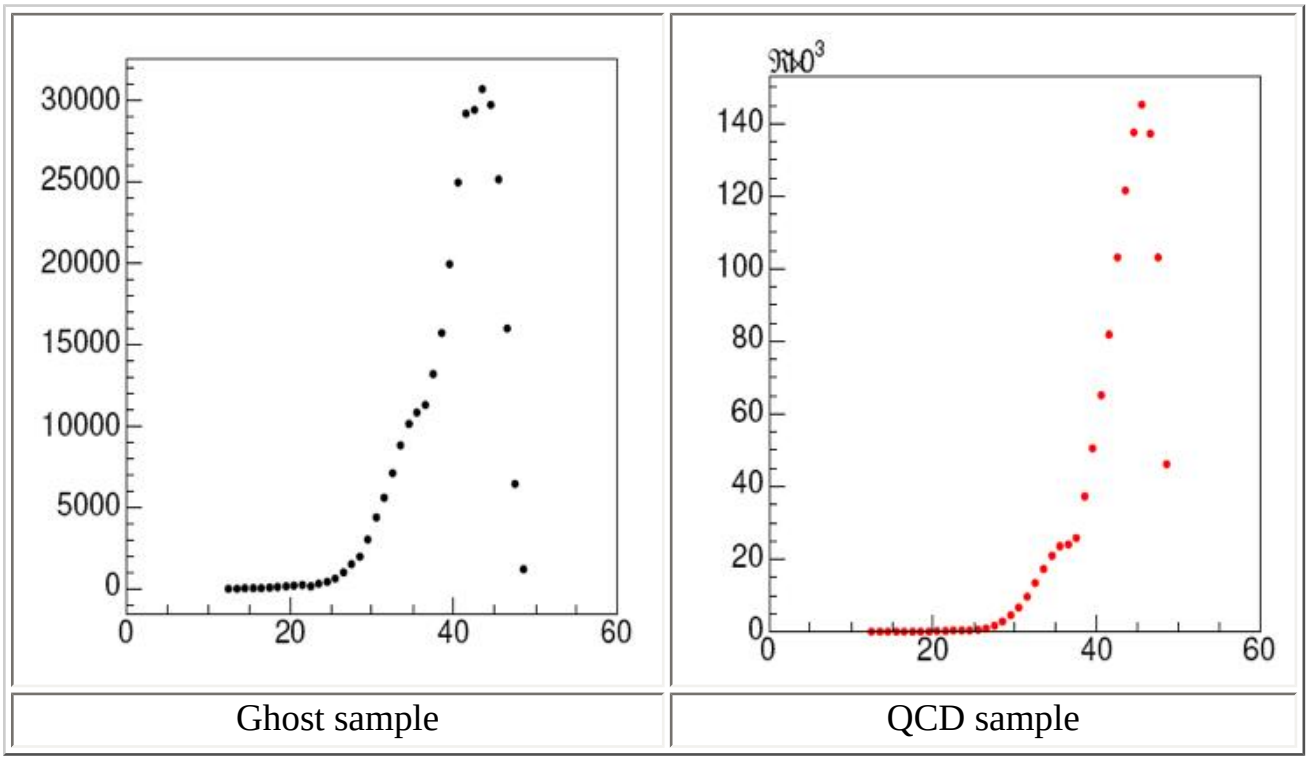


All muons



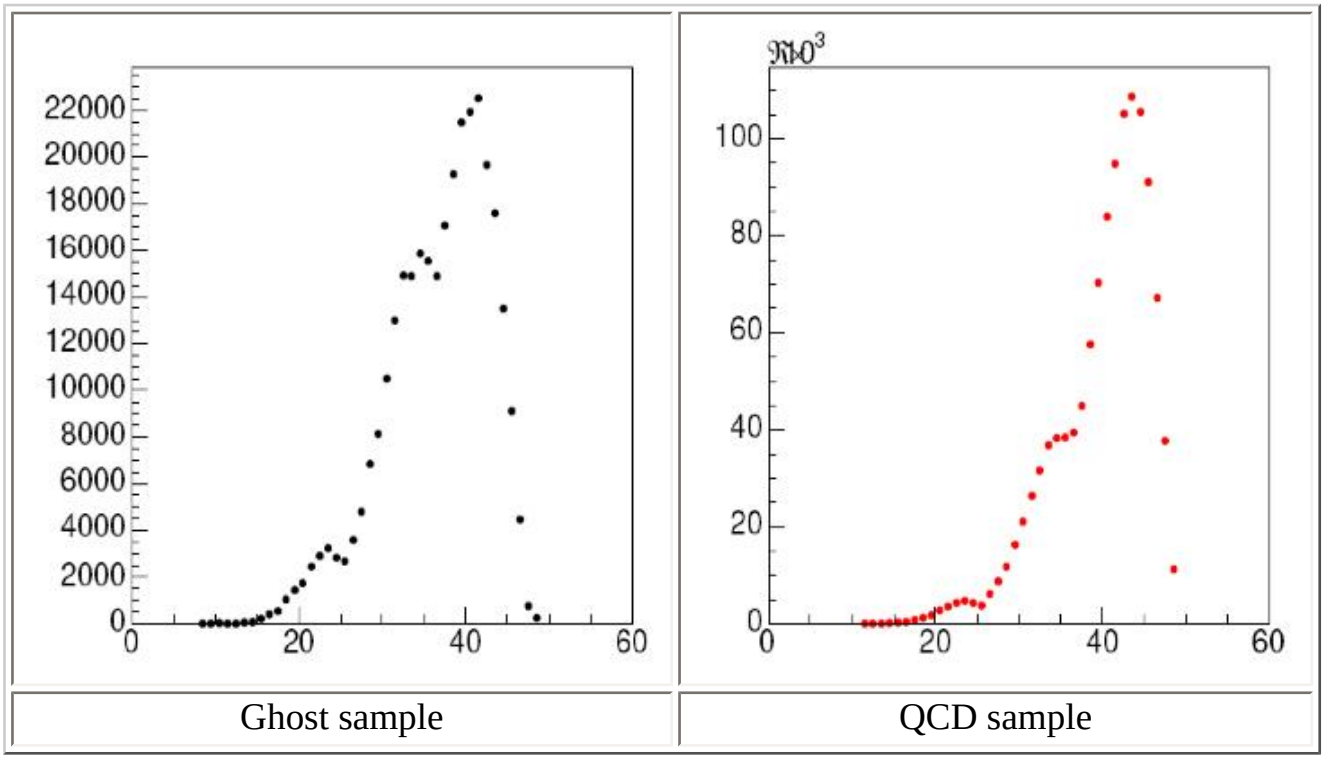
Tight SVX

6. Distribution of the number of hits of the associated axial layers for initial muons



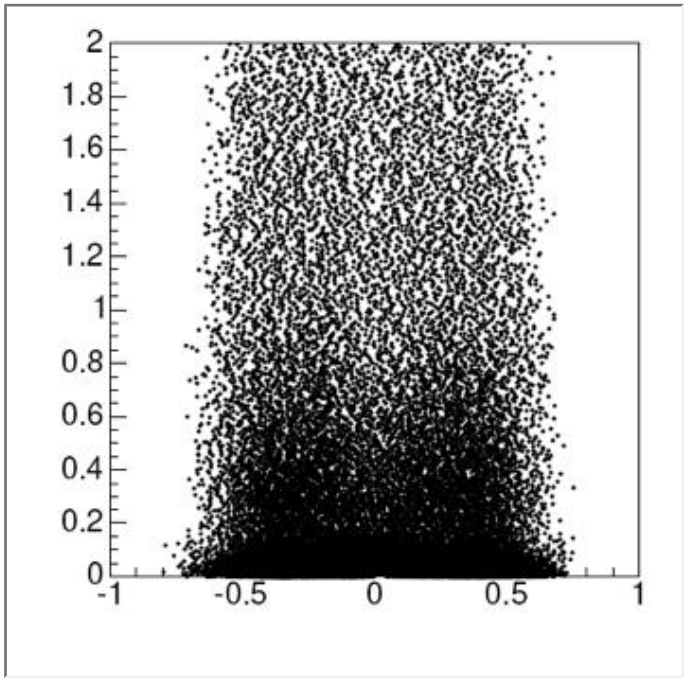
Ghost sample | QCD sample

7. Distribution of the number of associated stereo layer hits for initial muons

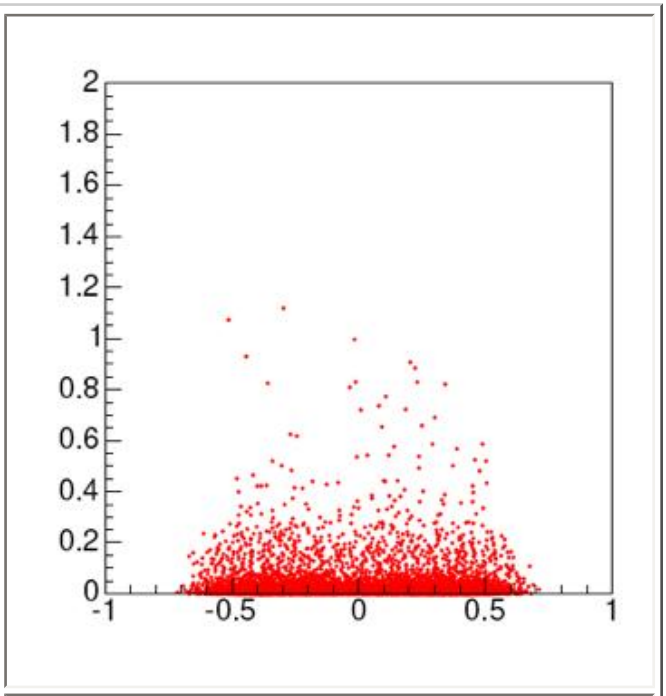


Ghost sample | QCD sample

8. d_0 versus η of initial muons



Ghost sample



QCD sample

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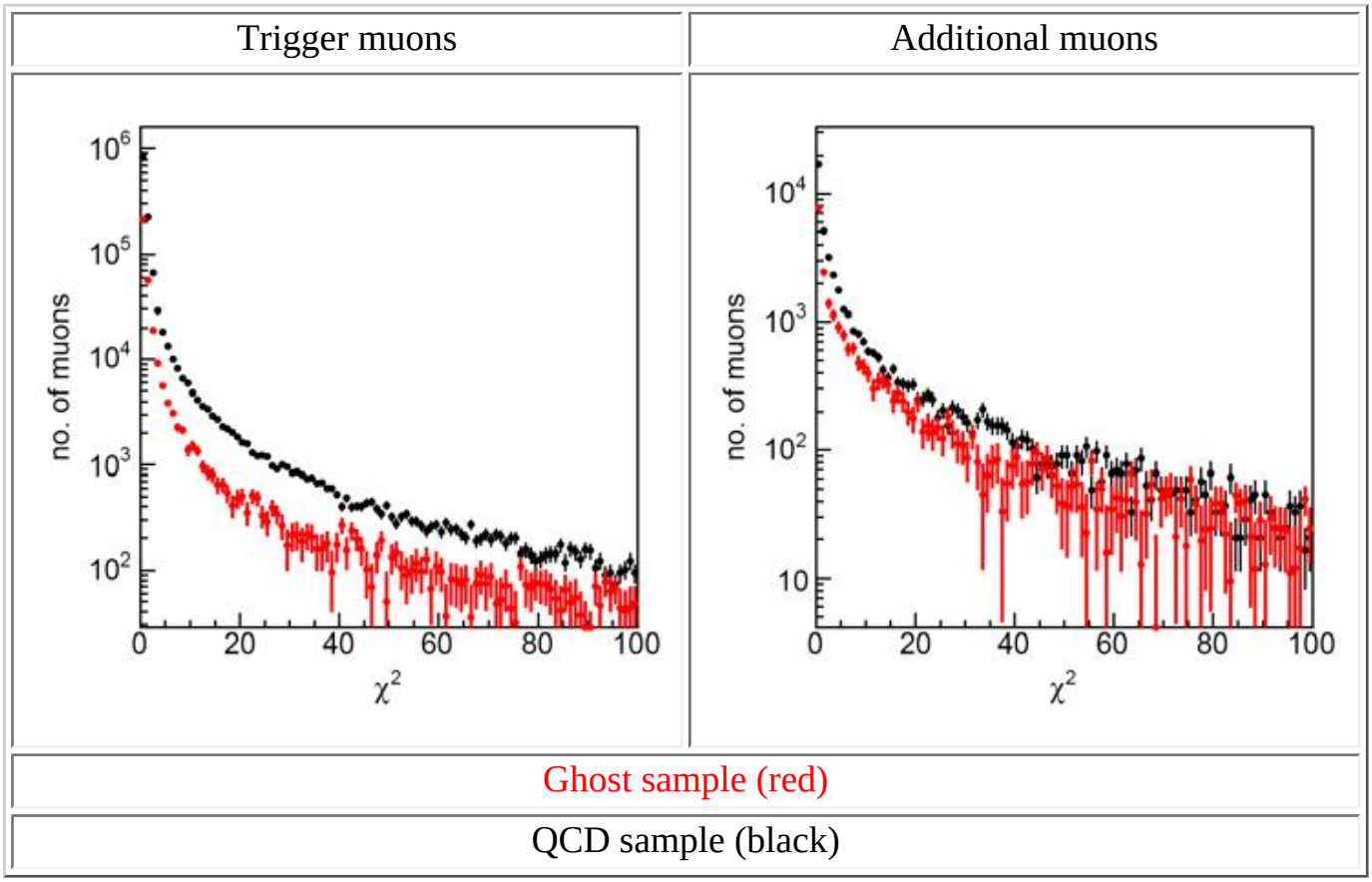
Plots related to muon quality

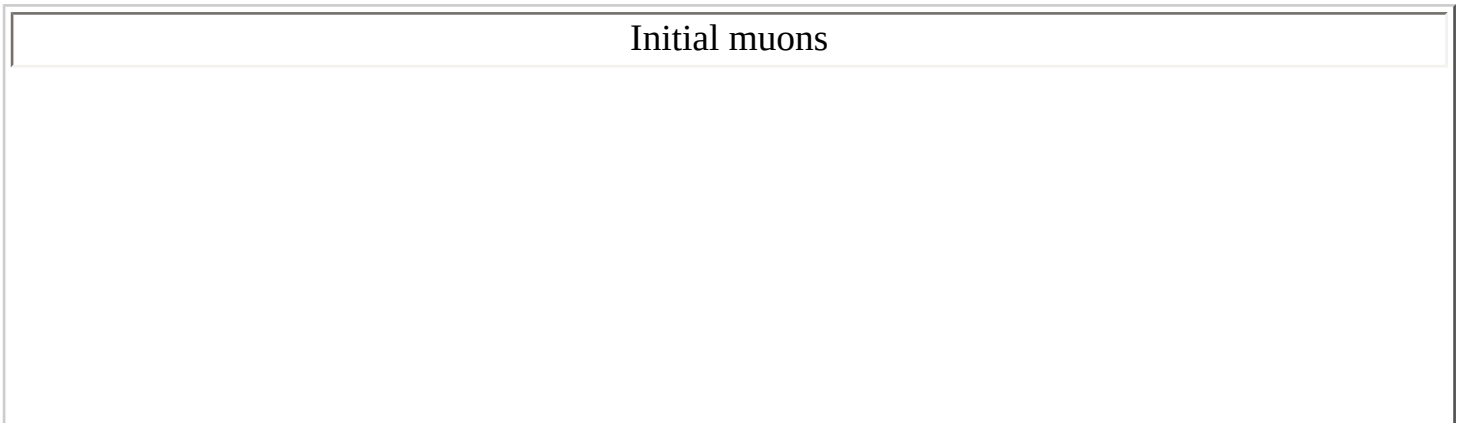
1. Composition of additional muons split according to detector type

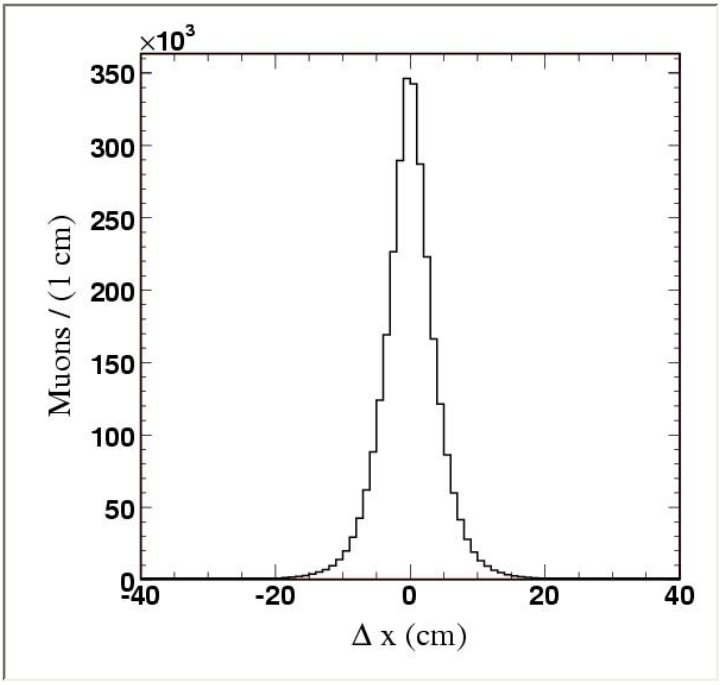
	CMU	CMP	CMUP	CMX
QCD	53%	26%	17%	4%
Ghost	60%	24%	14%	2%

2. r-φ matching χ^2 distributions of initial and additional muons

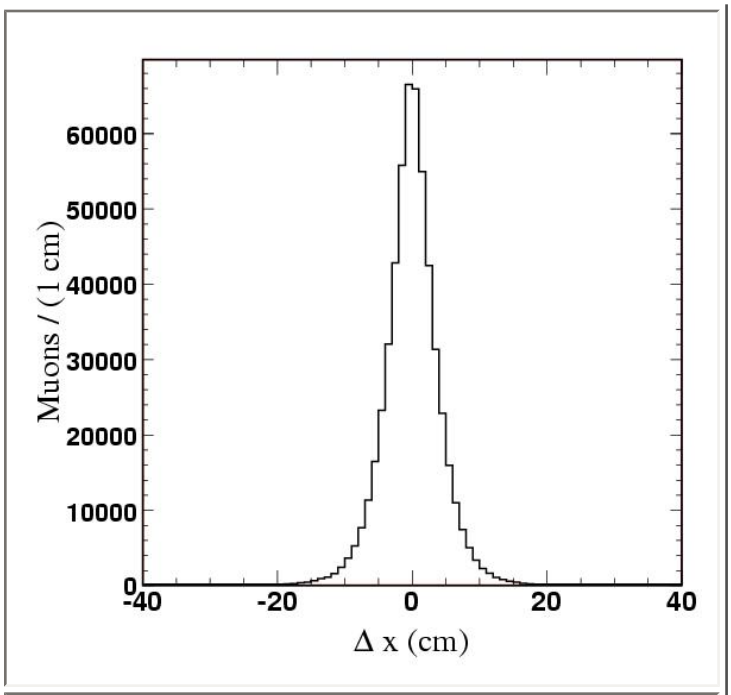


3. Δx distribution of trigger muons (CMUP)





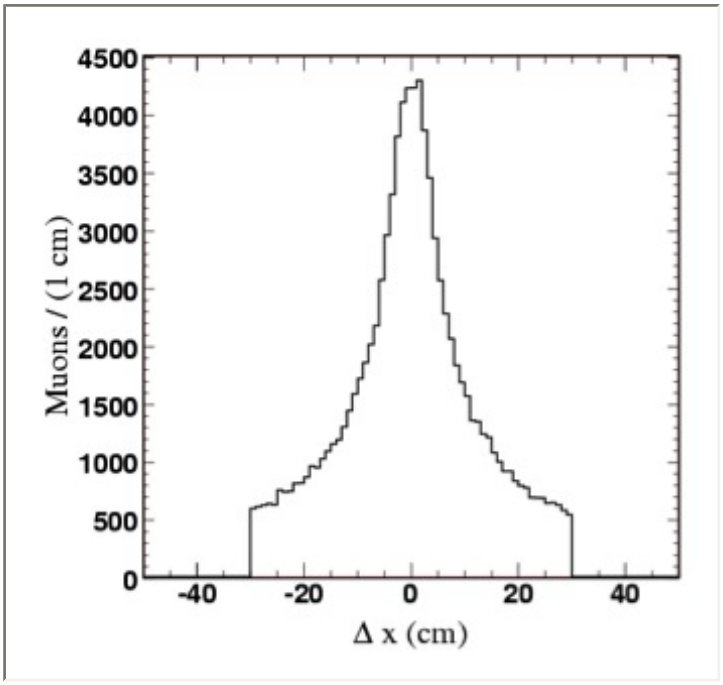
All muons



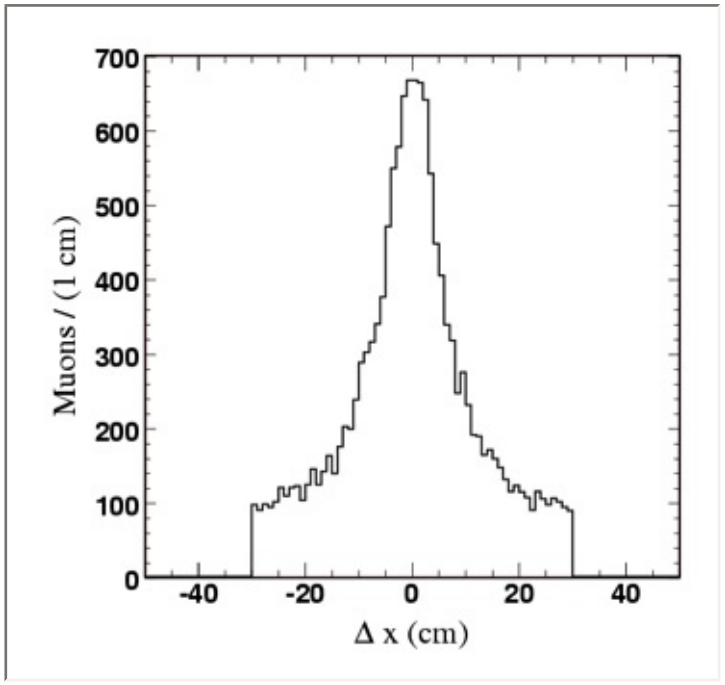
Tight SVX

4. Δx distribution of the additional muons split according to detector type

All additional muons - CMUP + CMU + CMX muons

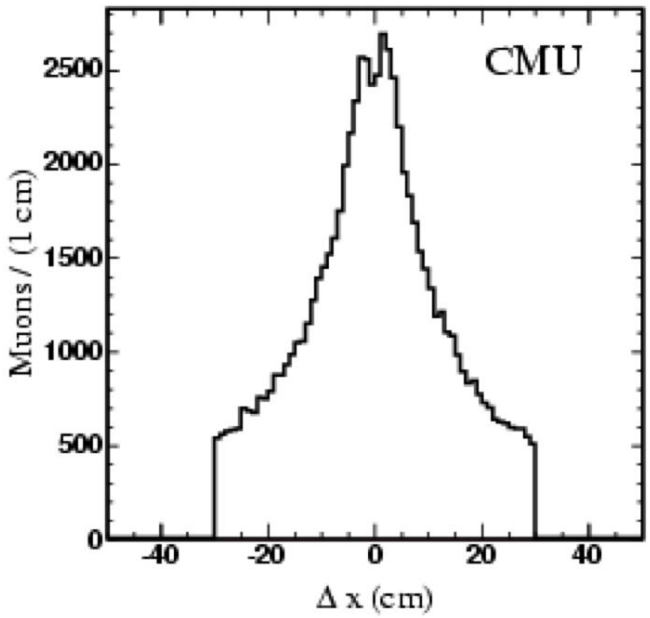


All muons

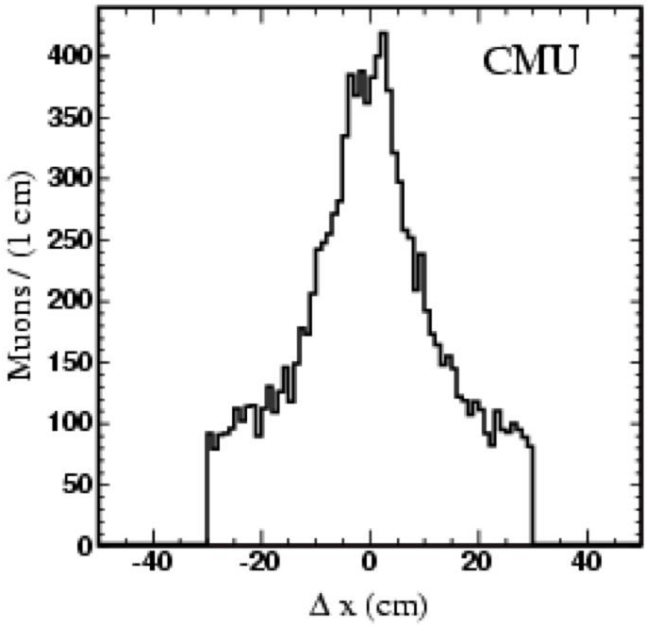


Tight SVX

Additional muons - CMU muons

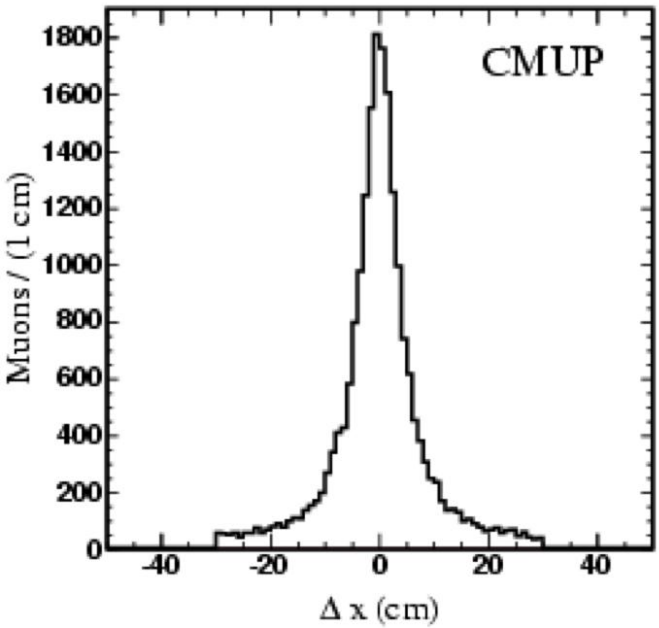


All muons

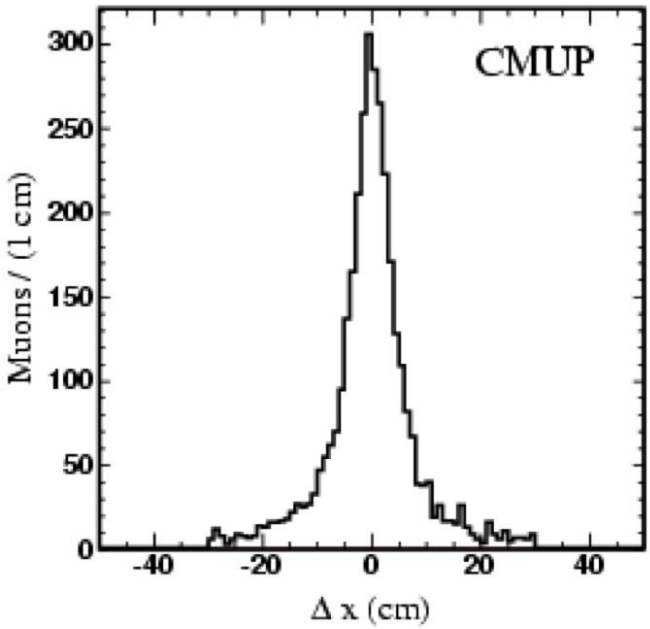


Tight SVX

Additional muons - CMUP muons

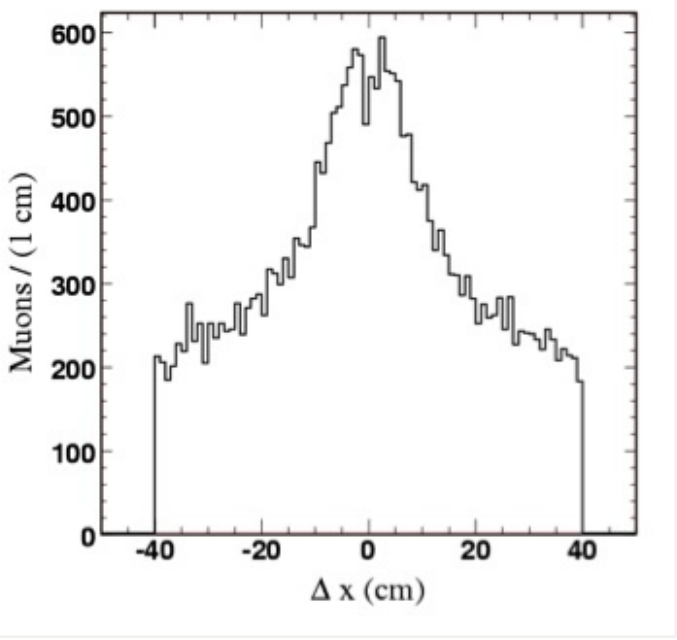


All muons

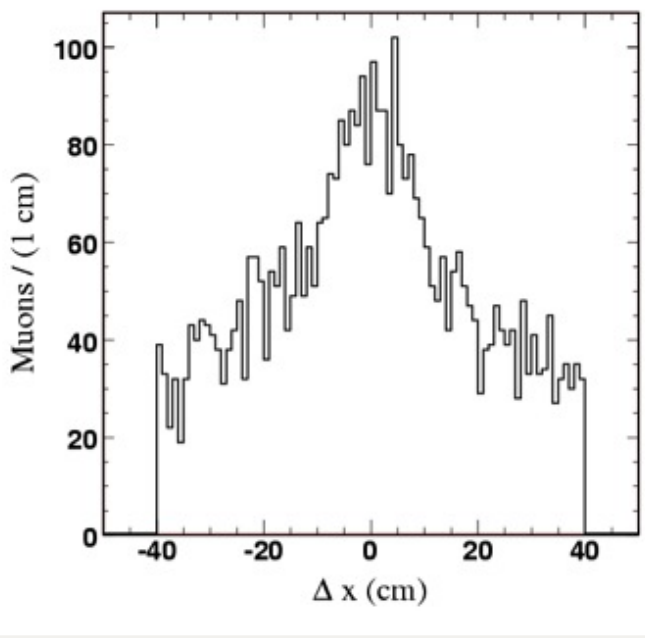


Tight SVX

Additional muons - CMP muons



All muons



Tight SVX

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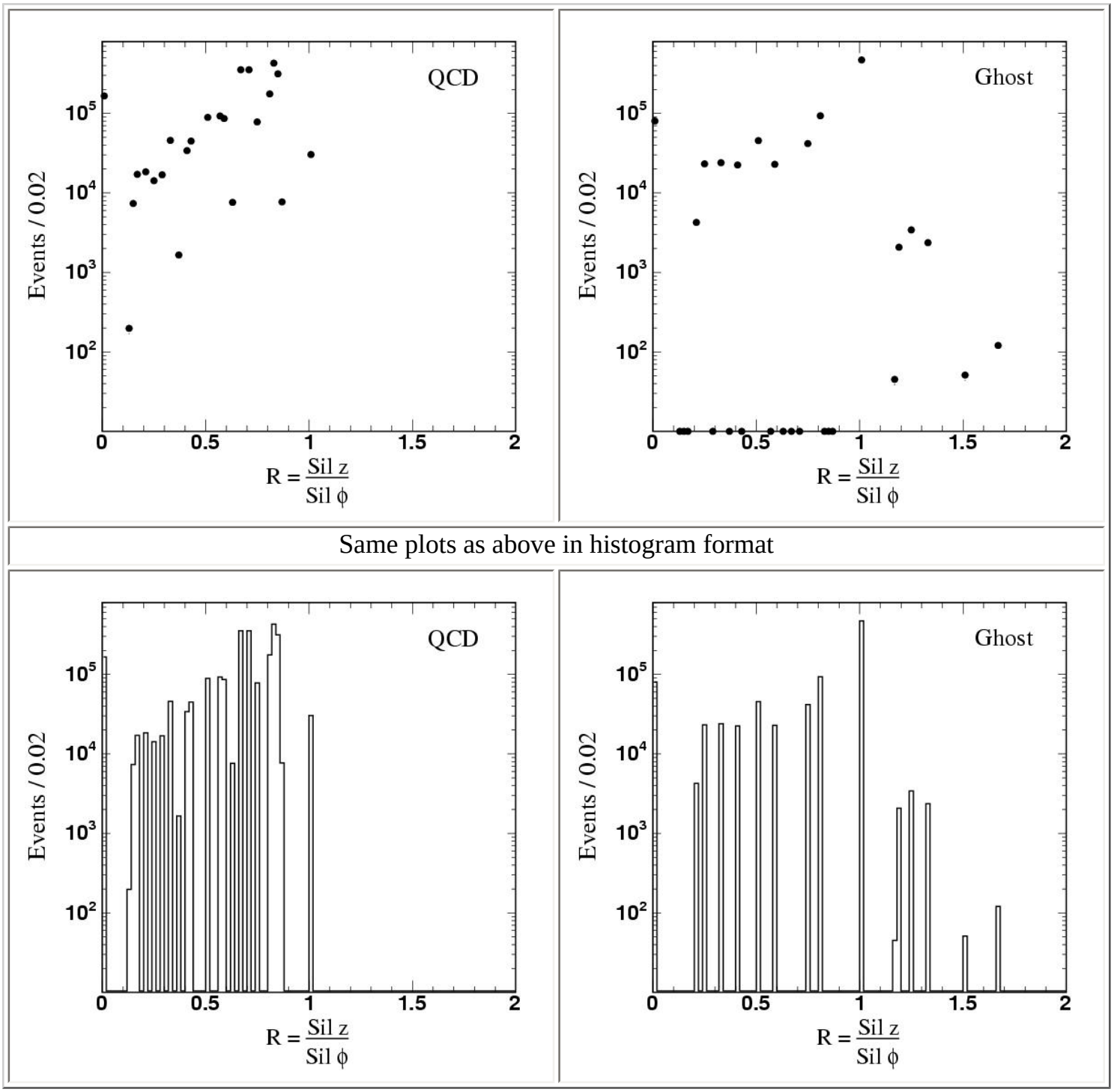
Plots related to the SVX hit distributions

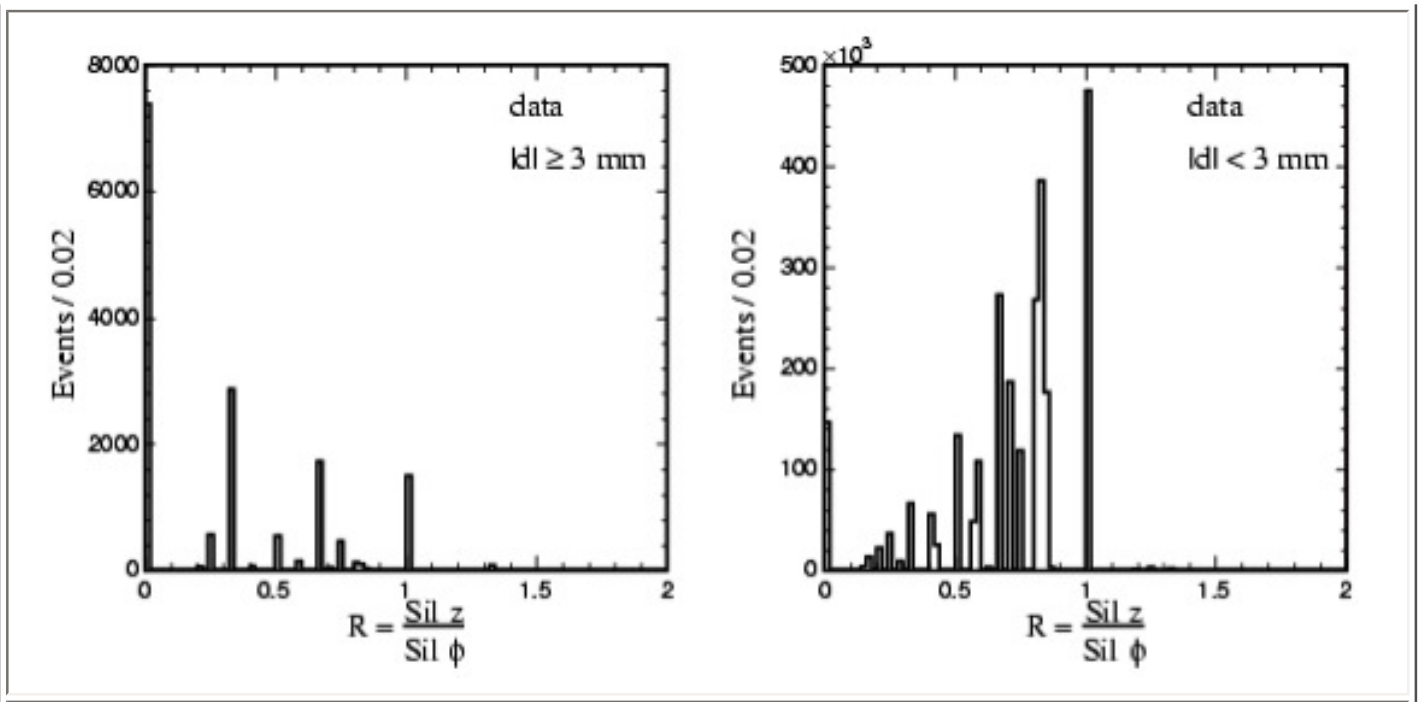
1. Ratio of z to &phi SVX hits for all muons in QCD and ghost events



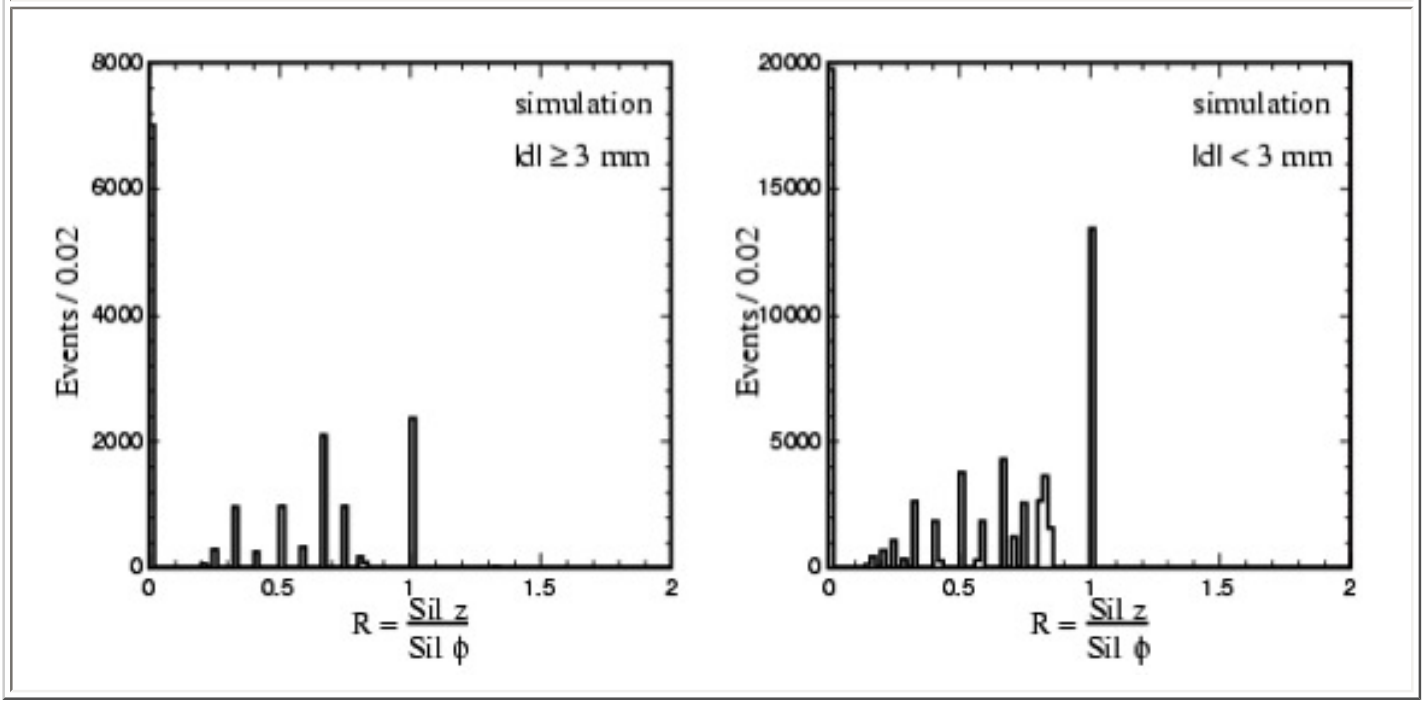
Same plots as above in histogram format

2. Ratio of z to &phi SVX hits for all muons in the data and simulation split according to the muon impact parameter

Data

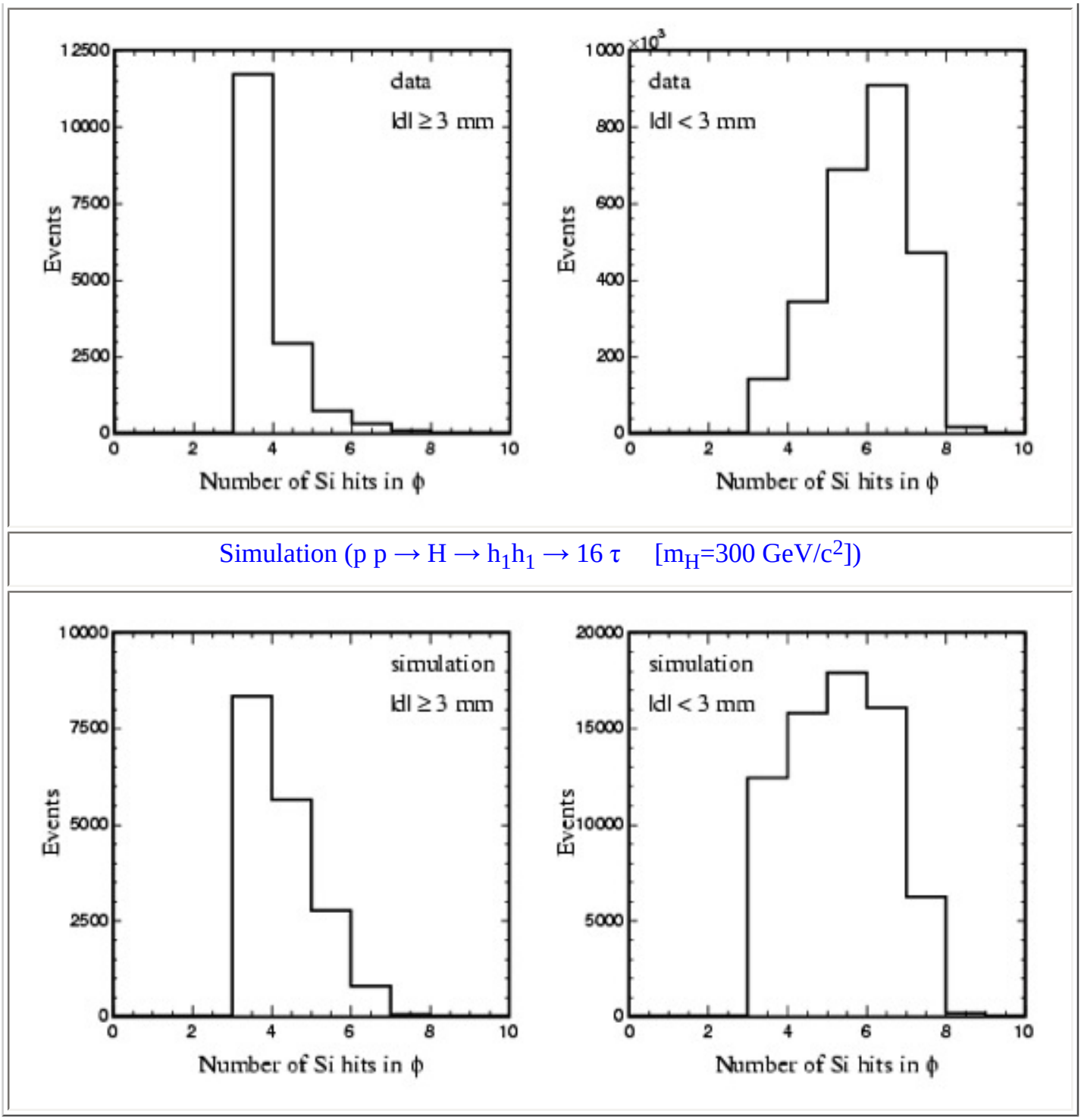


Simulation ($p\,p \rightarrow H \rightarrow h_1 h_1 \rightarrow 16\,\tau$ $[m_H=300\ GeV/c^2]$)



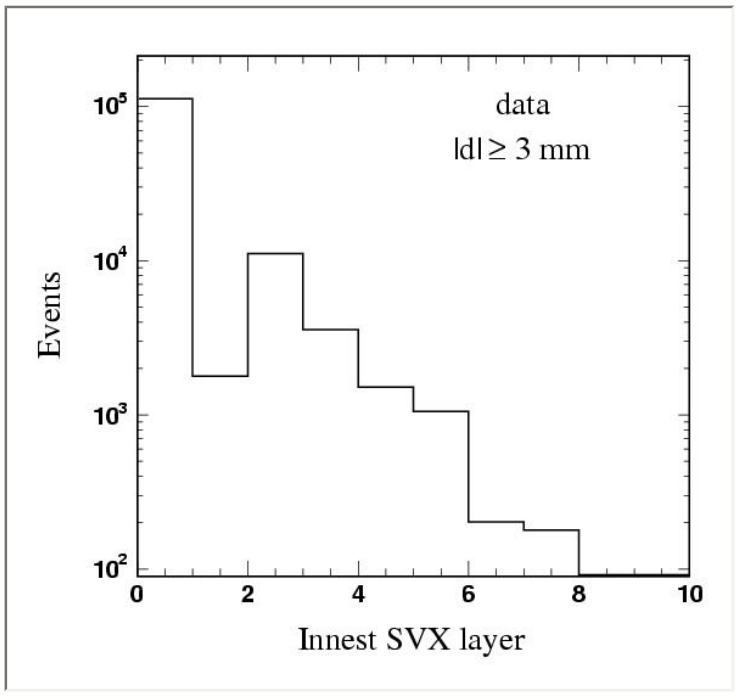
3. &phi SVX hits for all muons in the data and simulation split according to the muon impact parameter

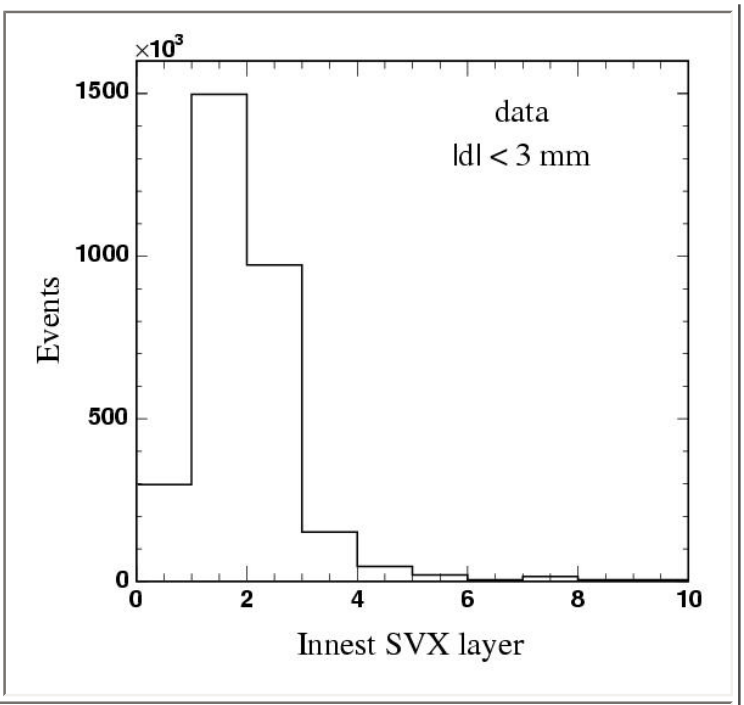
Data



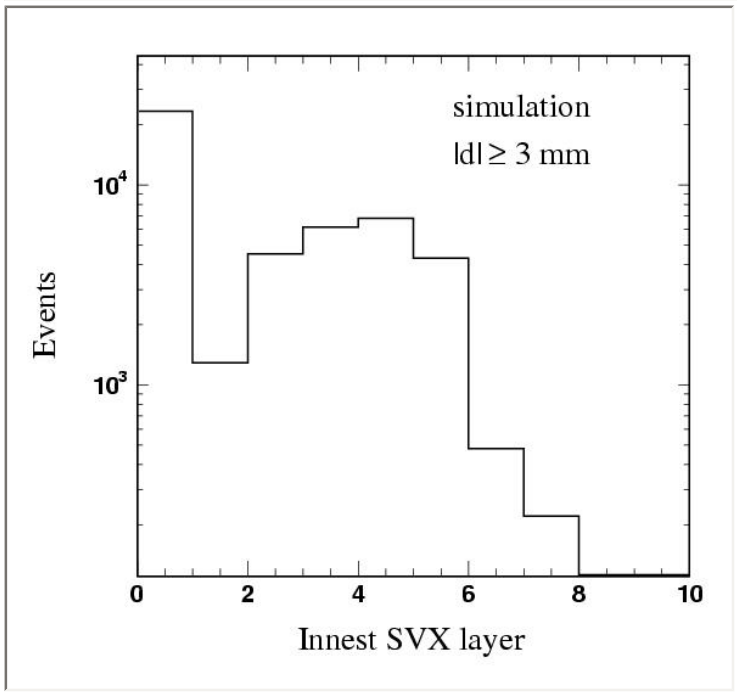
4. Distribution of the innermost SVX layer hit by the muon tracks in the data and simulation split according to the muon impact parameter. **Note that the first bin in all plots refers to cases where no SVX layer is hit.**

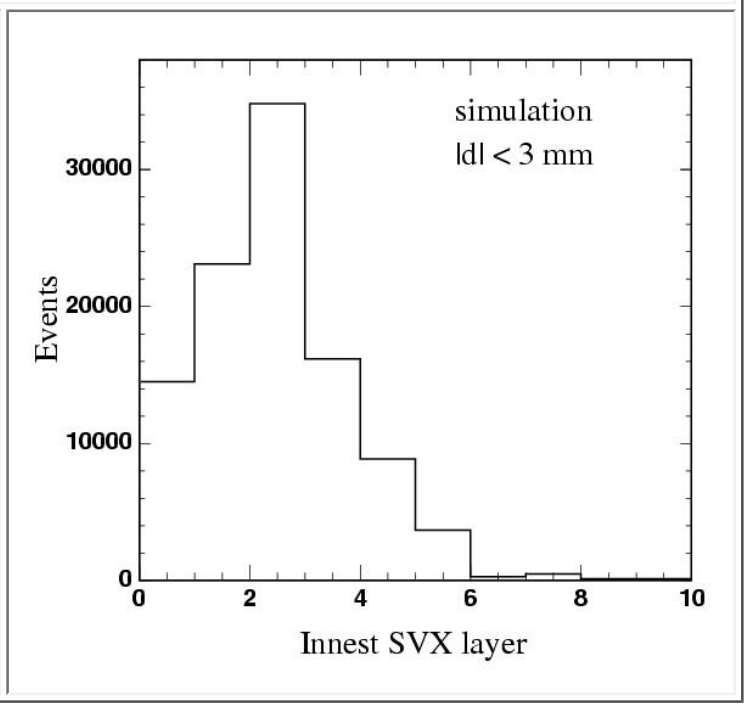
Data





Simulation ($p\,p \rightarrow H \rightarrow h_1 h_1 \rightarrow 16\,\tau$ $[m_H=300\ GeV/c^2]$)





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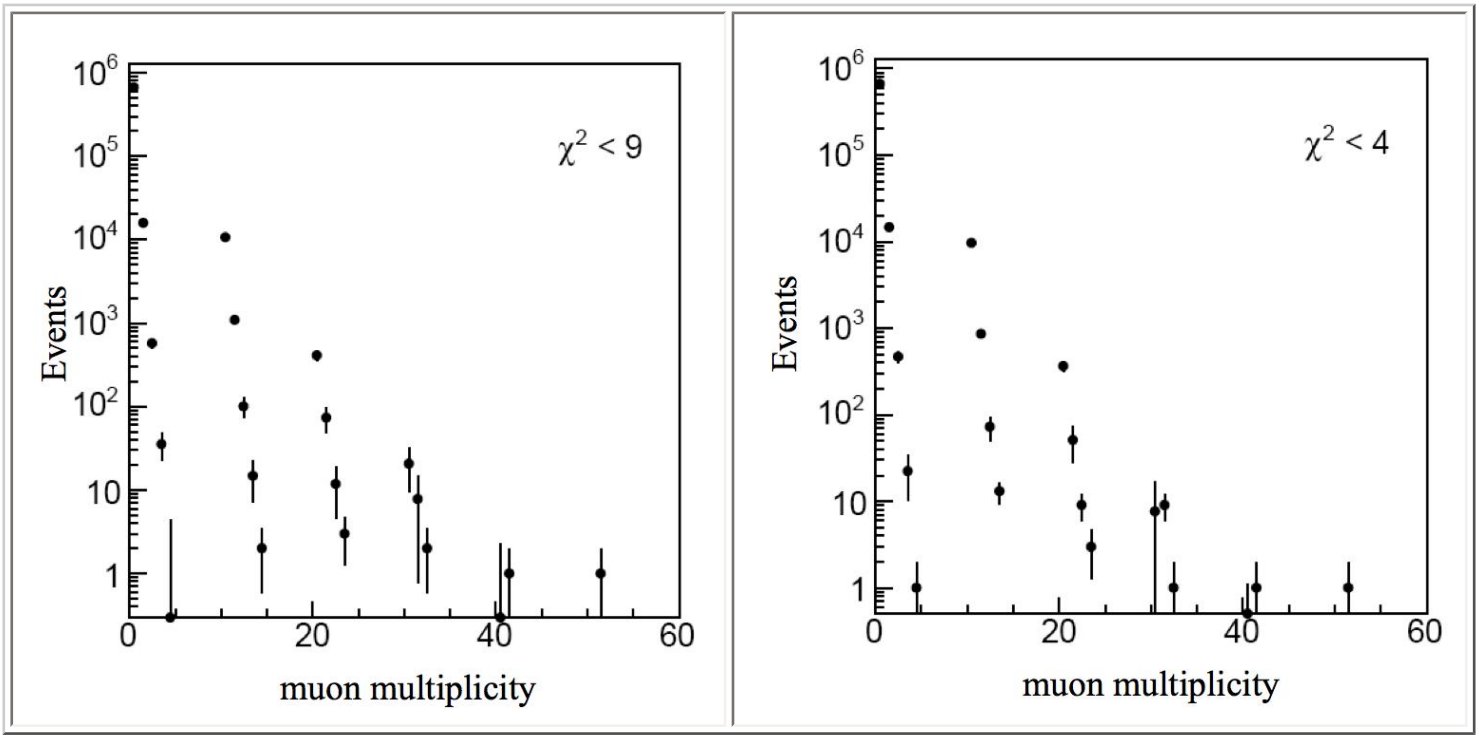
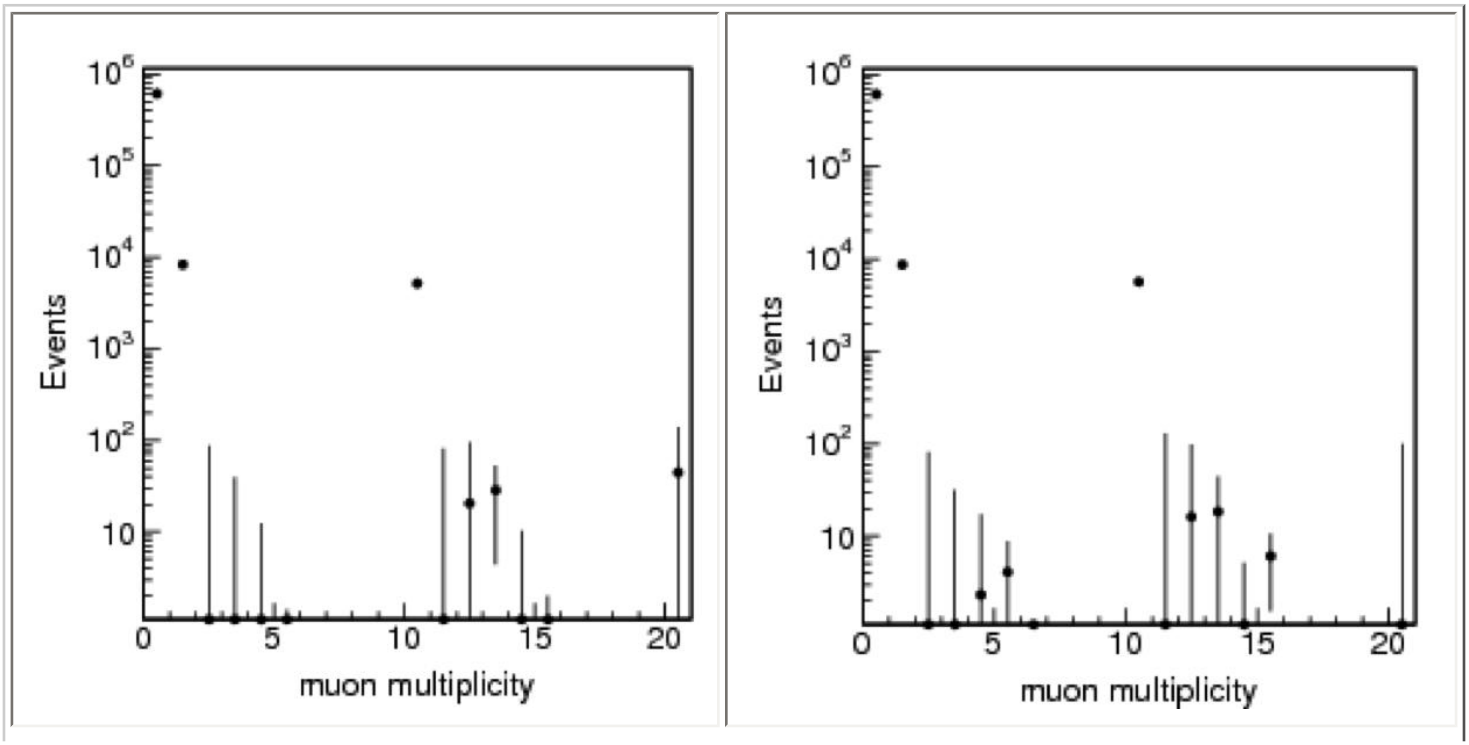
Plots related to the multiplicity of additional muons

1. Multiplicity distribution of additional muons found in 36.8ºcones when the muon r-φ matching $\chi^2 < 9$ and $\chi^2 < 4$.
   These distributions are not different than the standard one shown in Fig. 18 of the PRD draft.

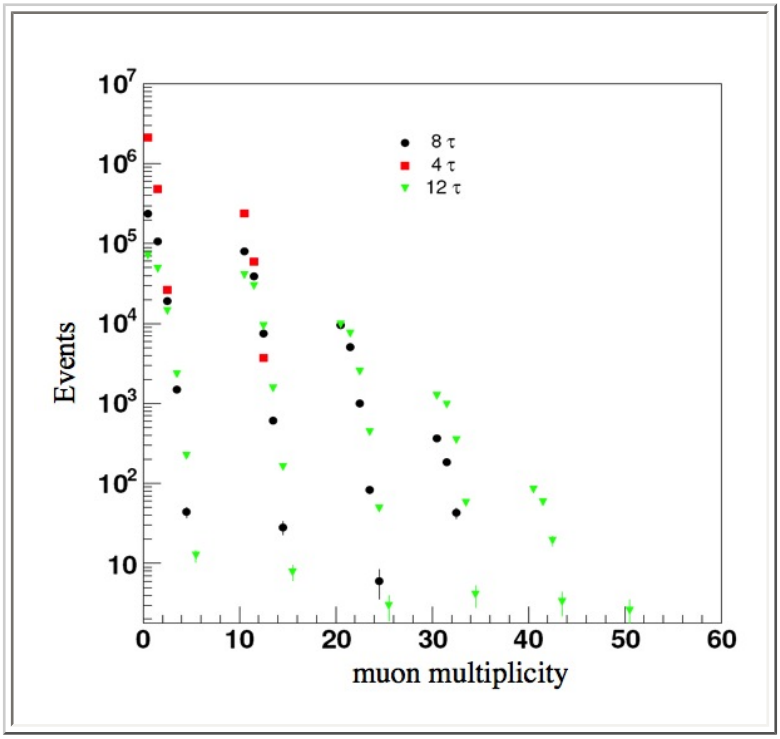


2. Multiplicity distribution of additional muons found in 36.8ºcones and 90º cone around the primary muon direction

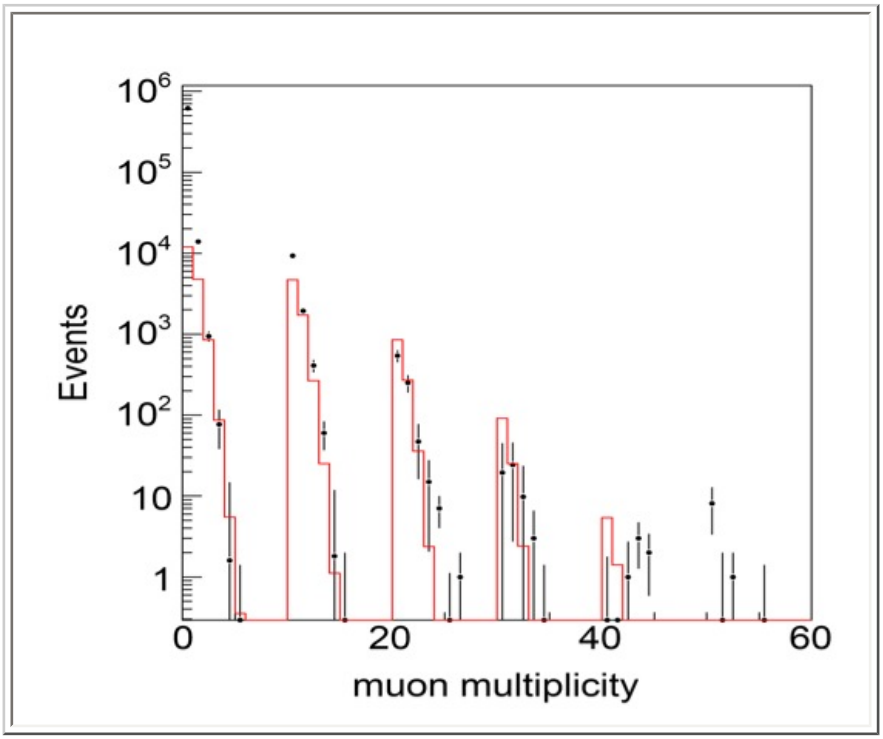


36.8º cone	90º cone

3. Muon multiplicity predicted by a toy-simulation of a decay into 4, 8 and 12 &tau leptons.



4. Muon multiplicity predicted by a toy-simulation of a decay into 8 &tau leptons with randomly chosen electric charge.



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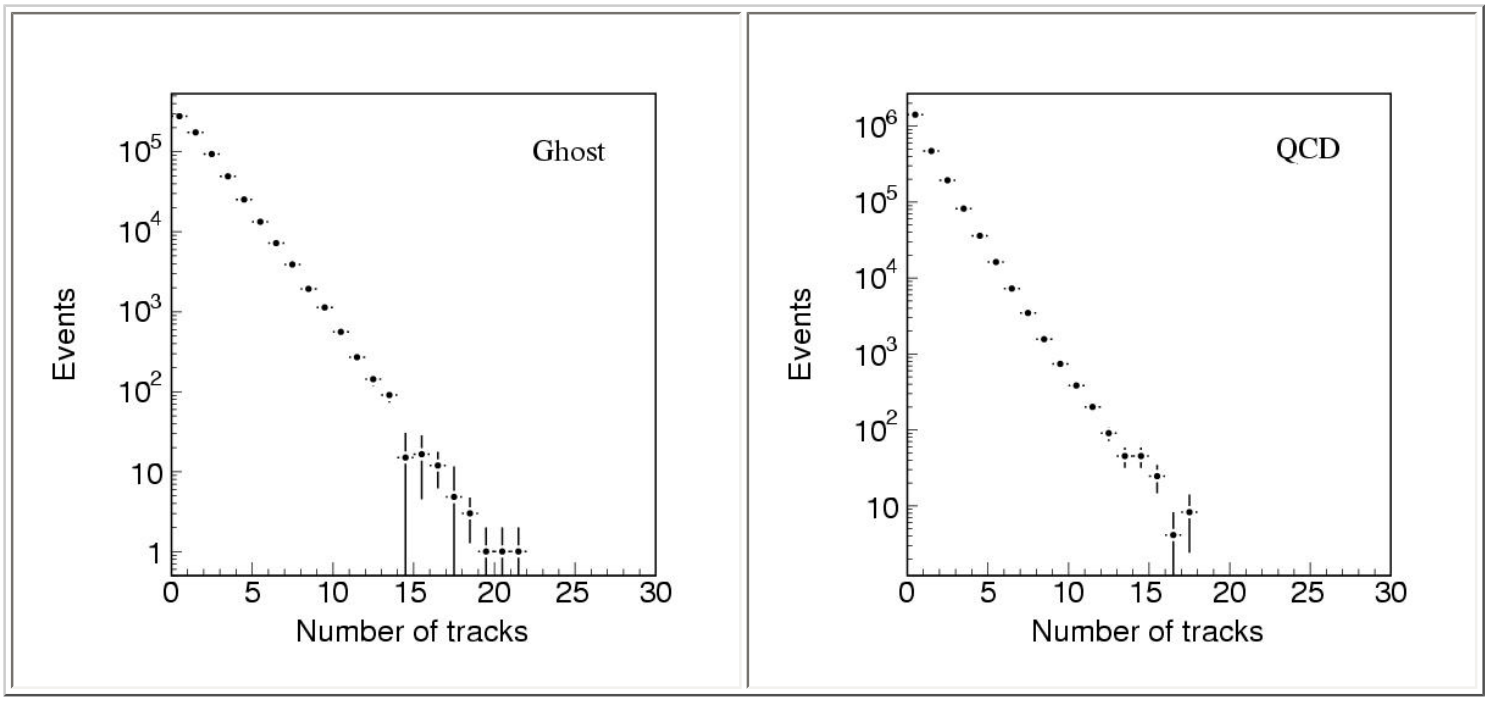
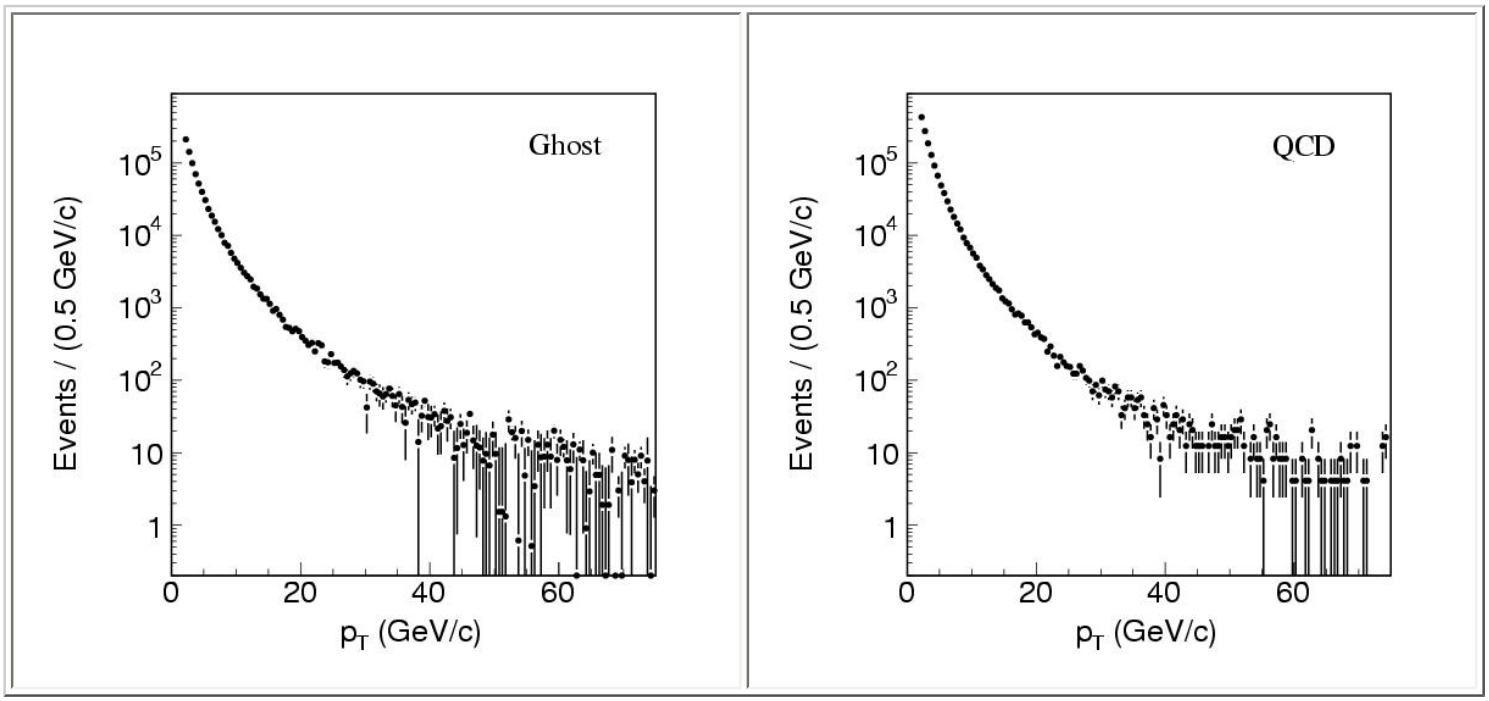
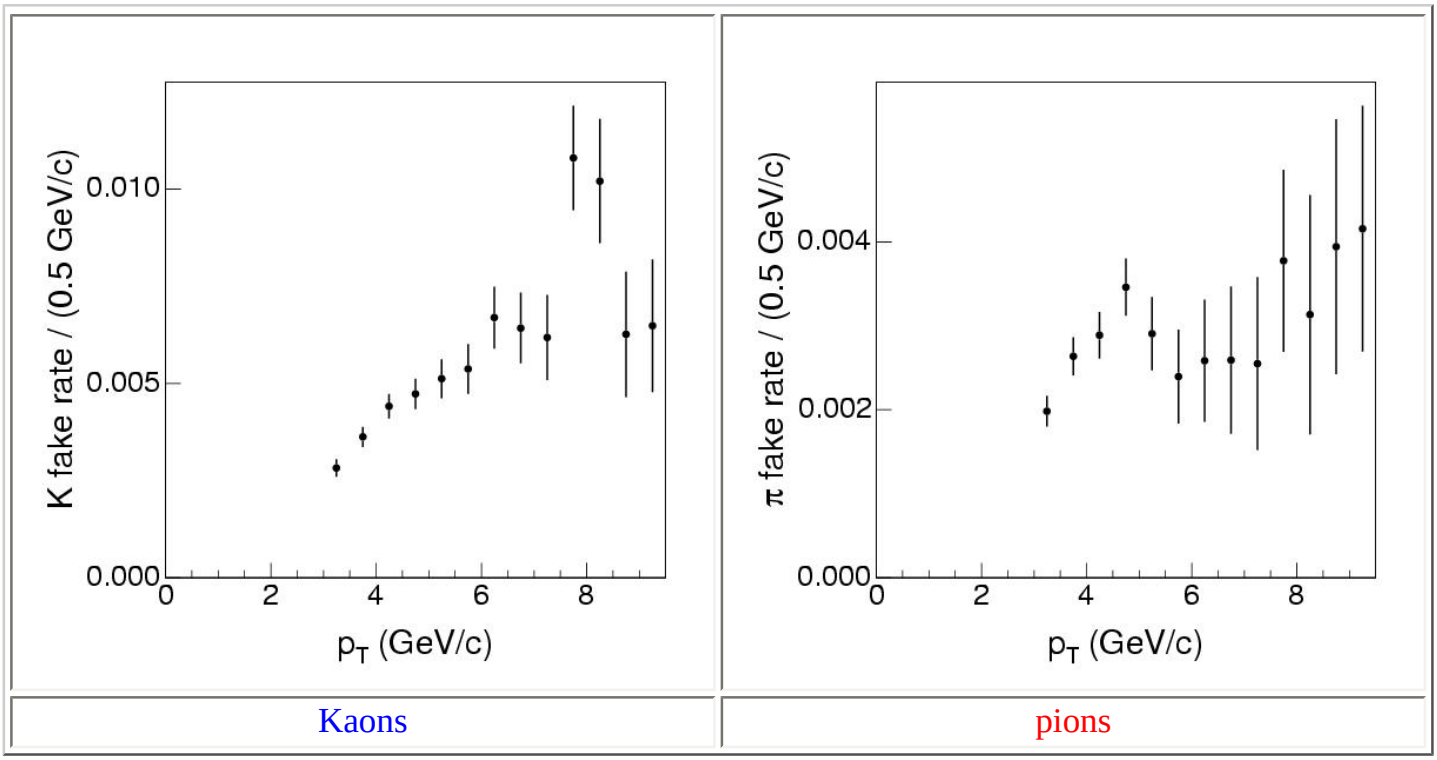
1. Track multiplicity distribution in QCD and ghost events. We count tracks with $p_T > 2$ GeV/c and $|\eta| < 1.1$



2. Transverse momentum distribution of tracks in QCD and ghost events.



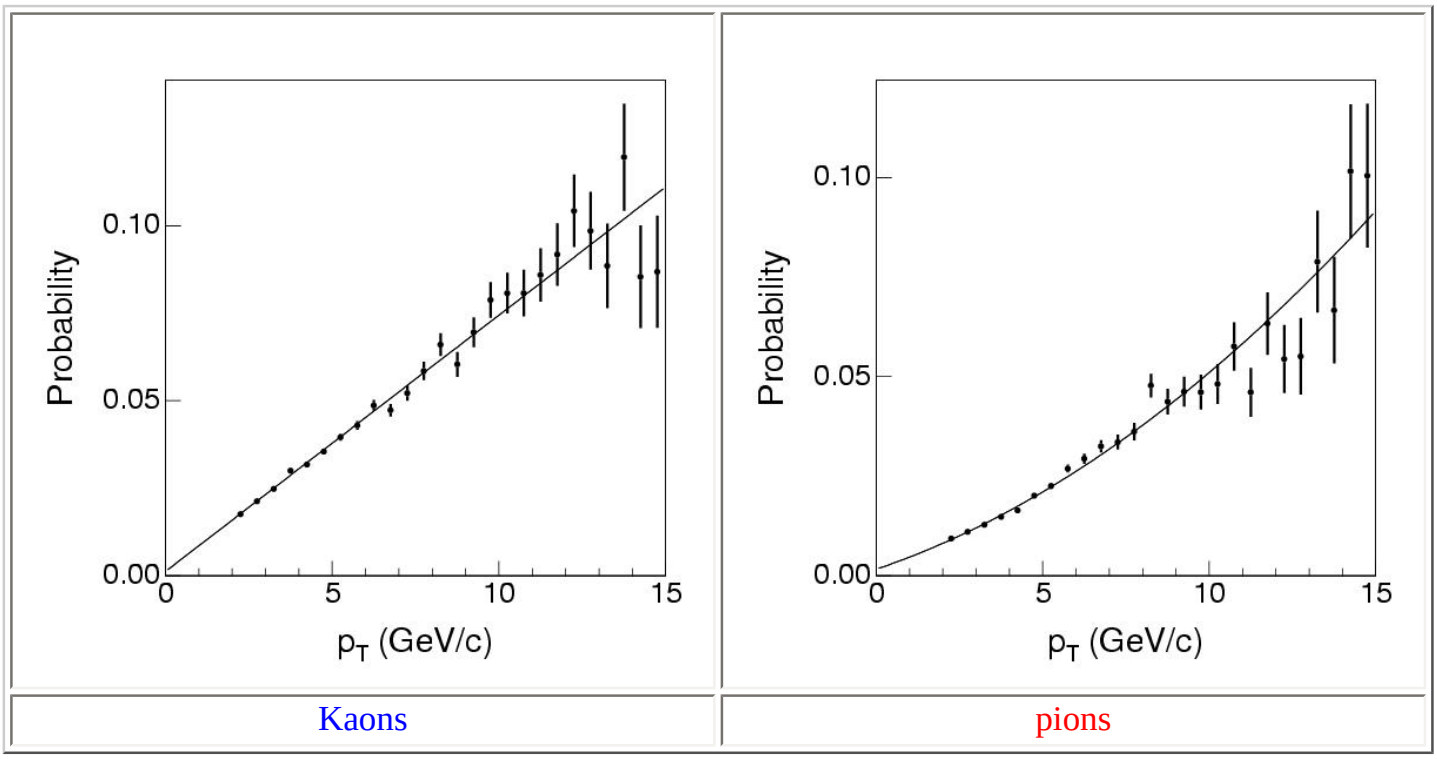
3. Fake muon probability as a function of the kaon (left) and pion (right) p_T for CMUP muons. The plot is from the correlated bb PRD.



Kaons | pions

4. Fake muon probabilities in the CMU, CMP, CMUP and CMX detectors as a function of the kaon (left) and pion (right) p_T.

   The fake rate is the weighted average of CMU, CMP, CMUP and CMX muons. This is Fig. 10 of the current PRD draft



Kaons | pions

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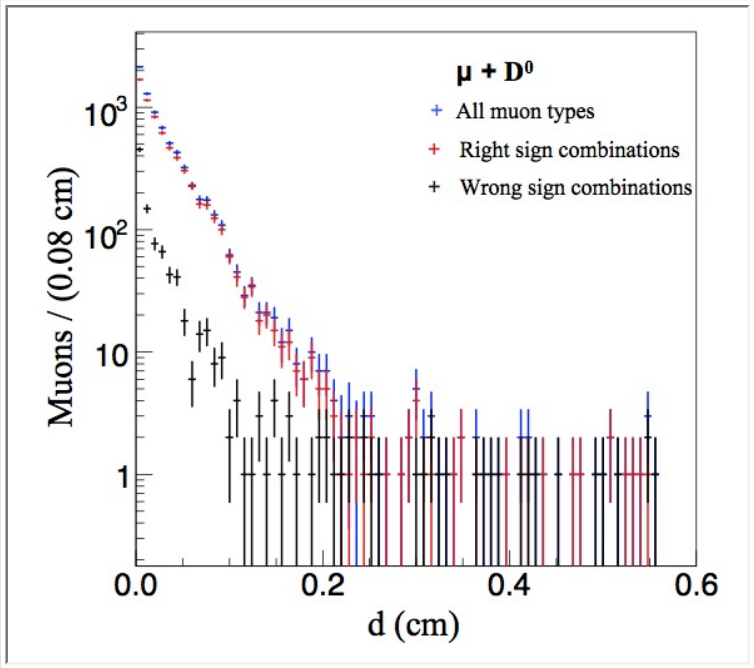
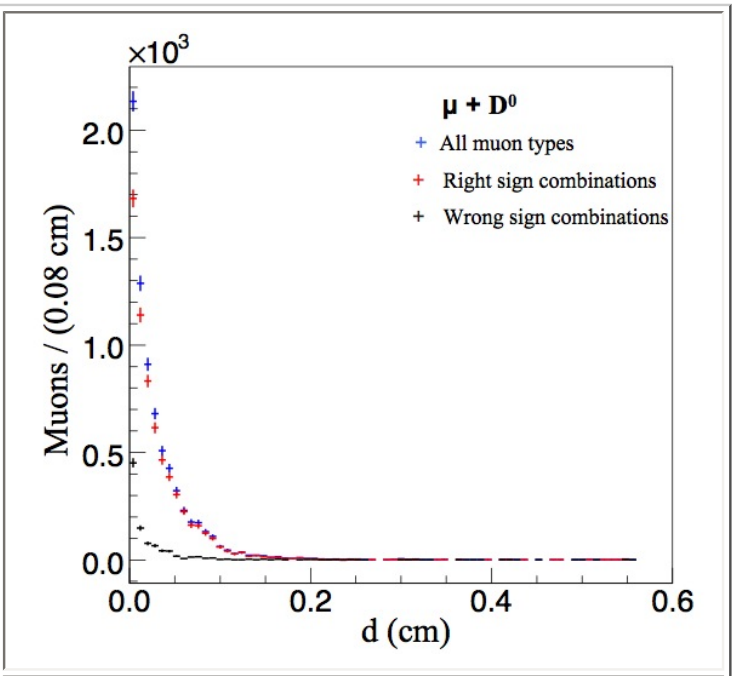
1. Impact parameter distribution of all muon types (CMU, CMP, CMUP, CMX) with $p_T > 2$ GeV/c that are found around a $D^0 \rightarrow \pi K$. The points in red are for right sign combinations and in black for wrong sign combinations. The points of the wrong sign combinations show the low level contribution of fake muons.



Log scale



Linear scale

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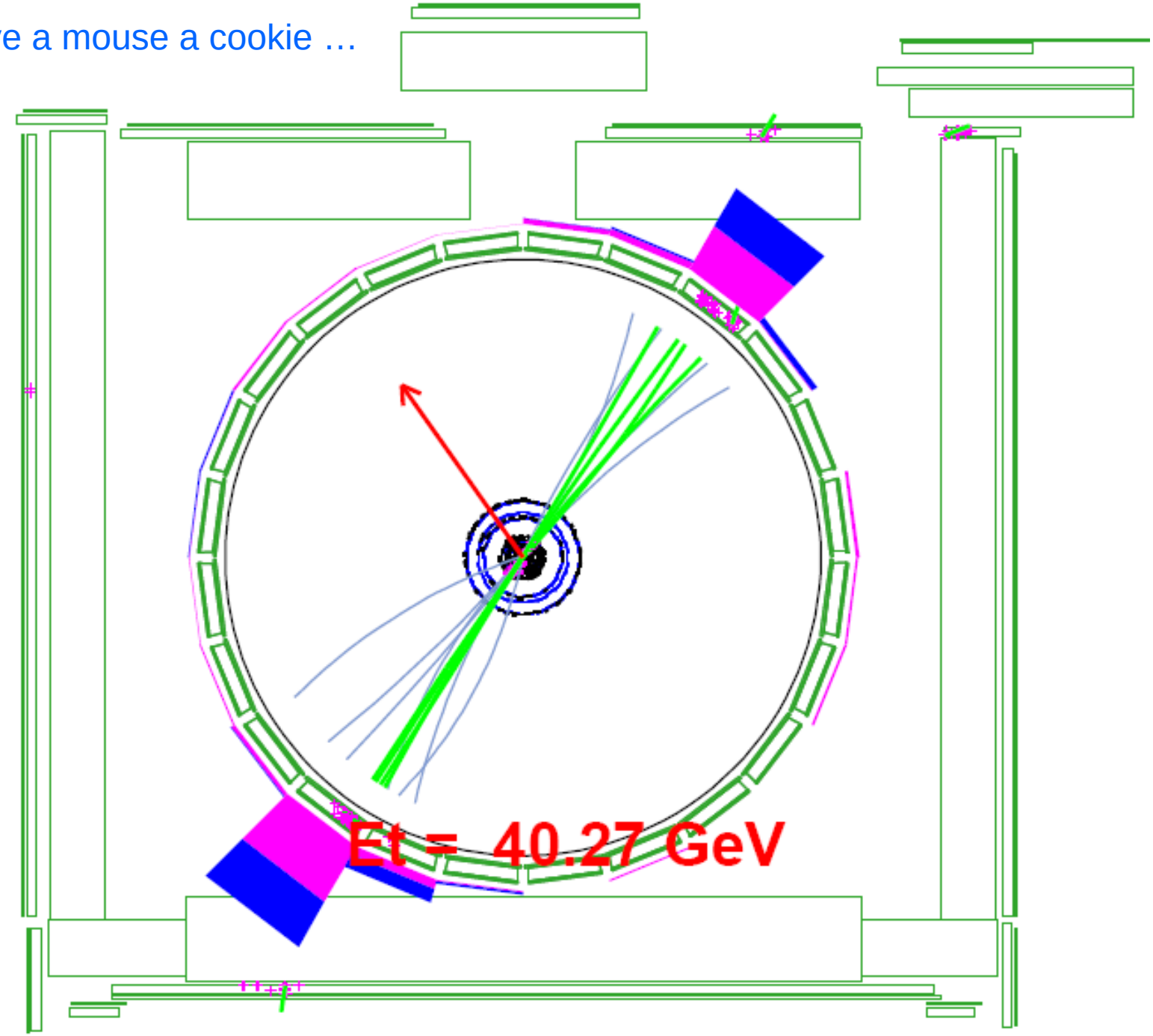
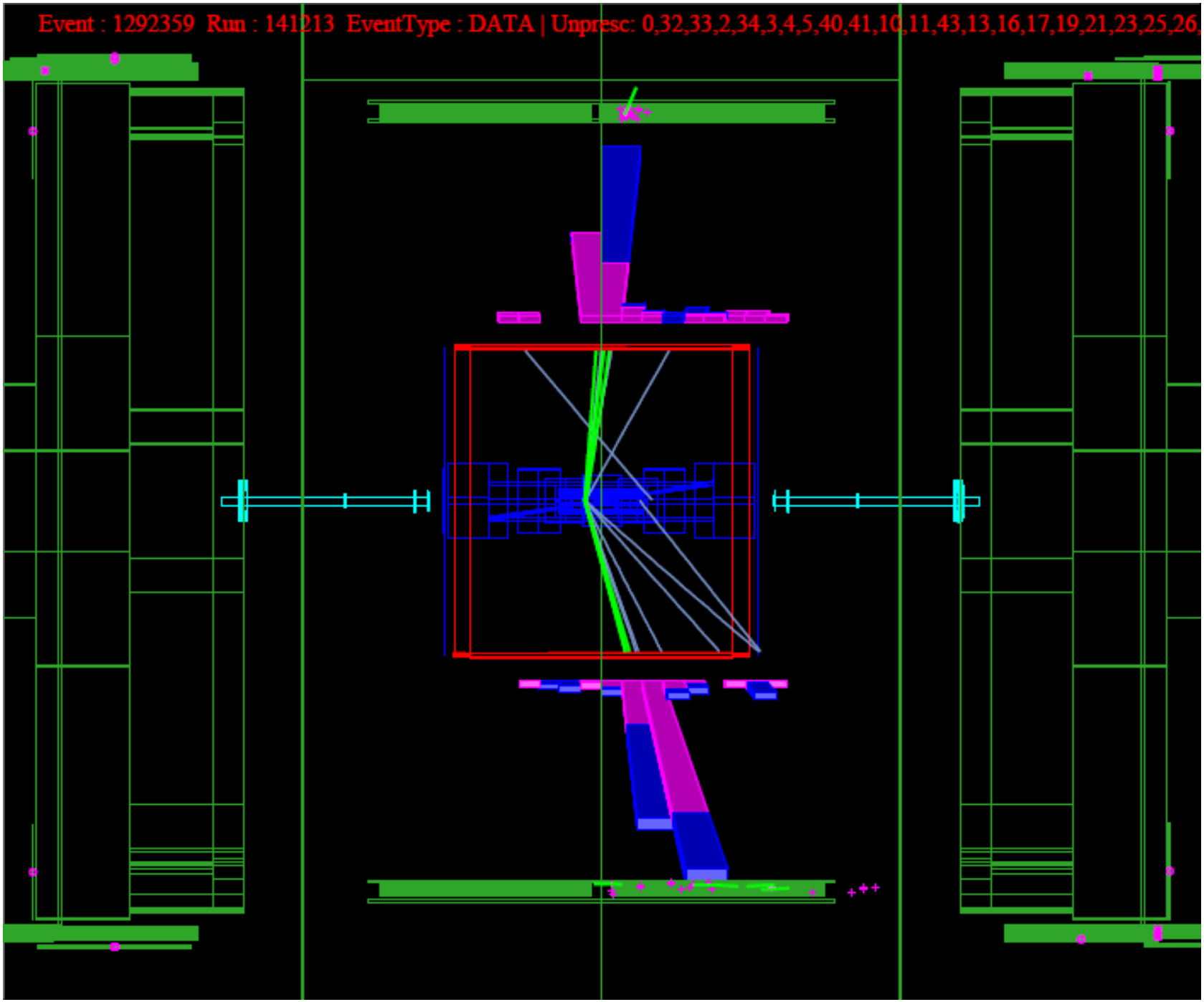
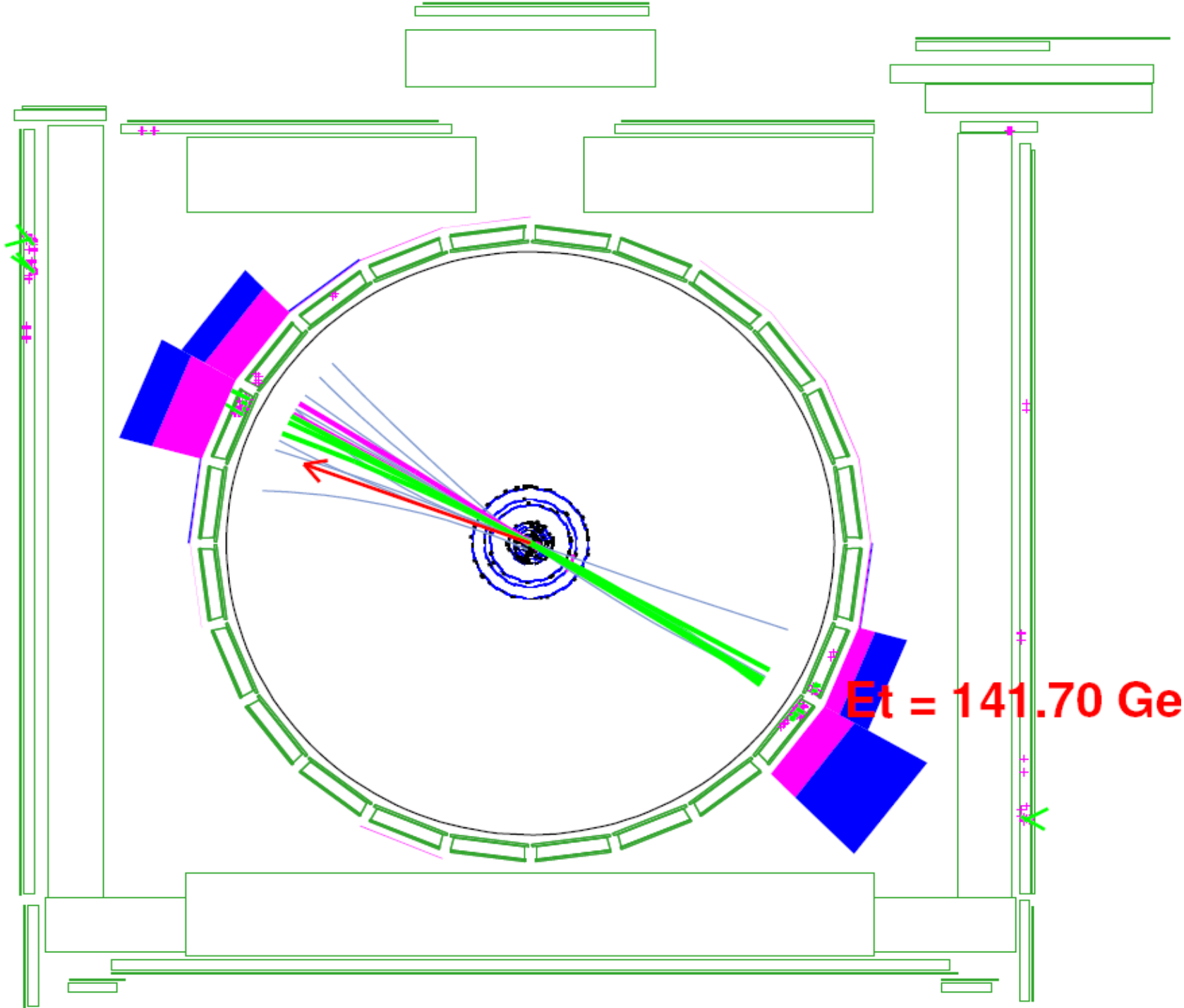
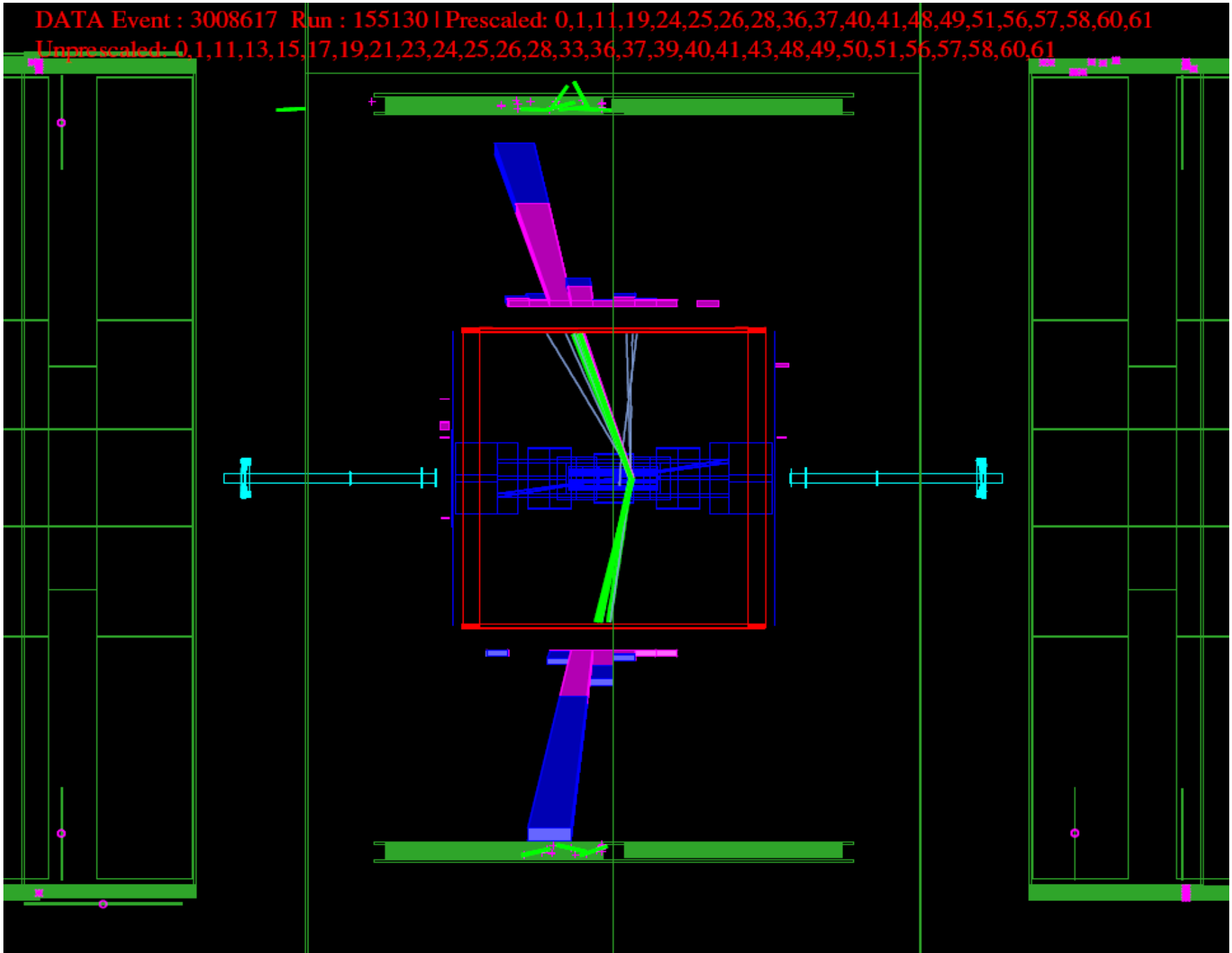
Event parade

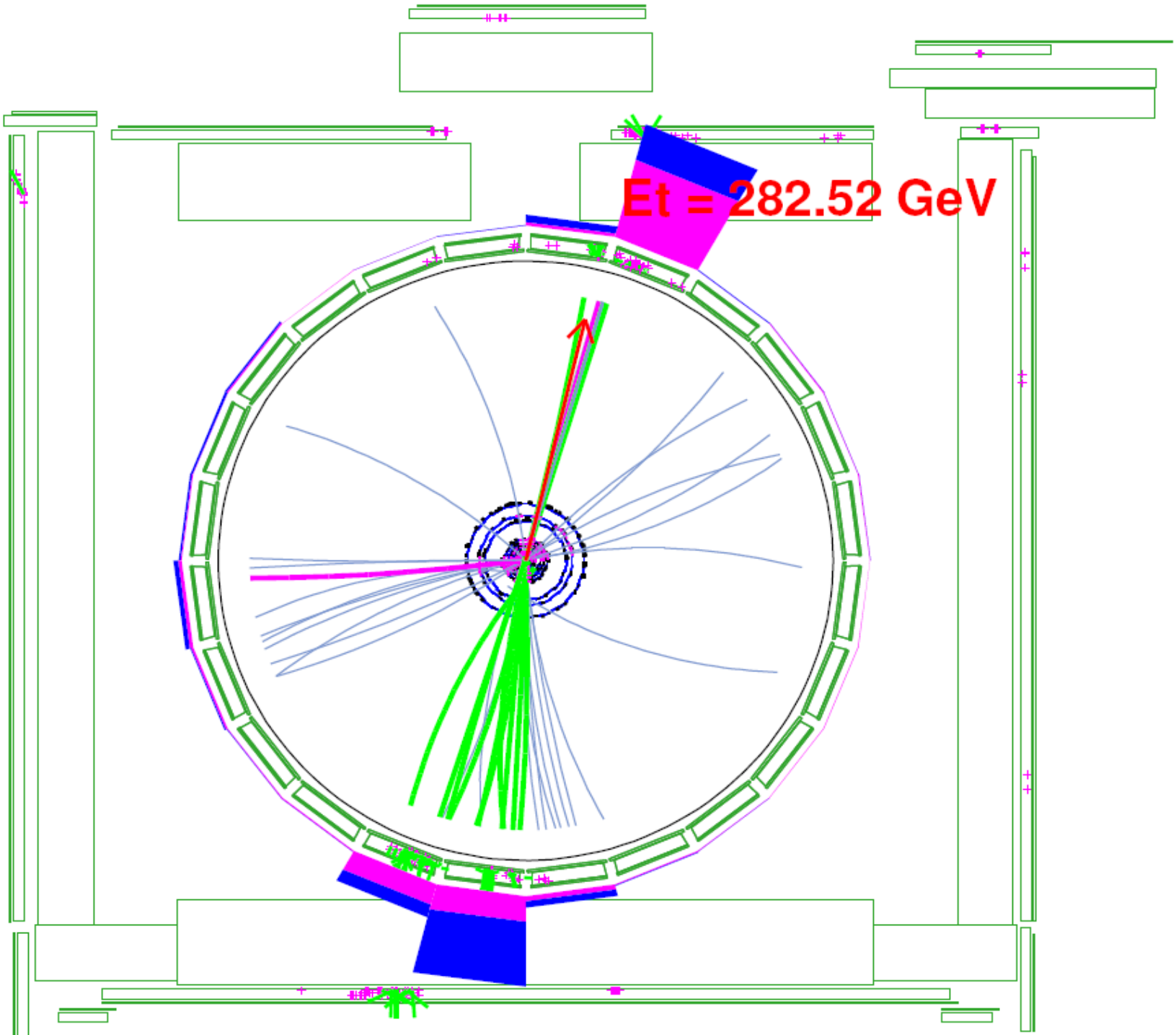
If you give a mouse a cookie …



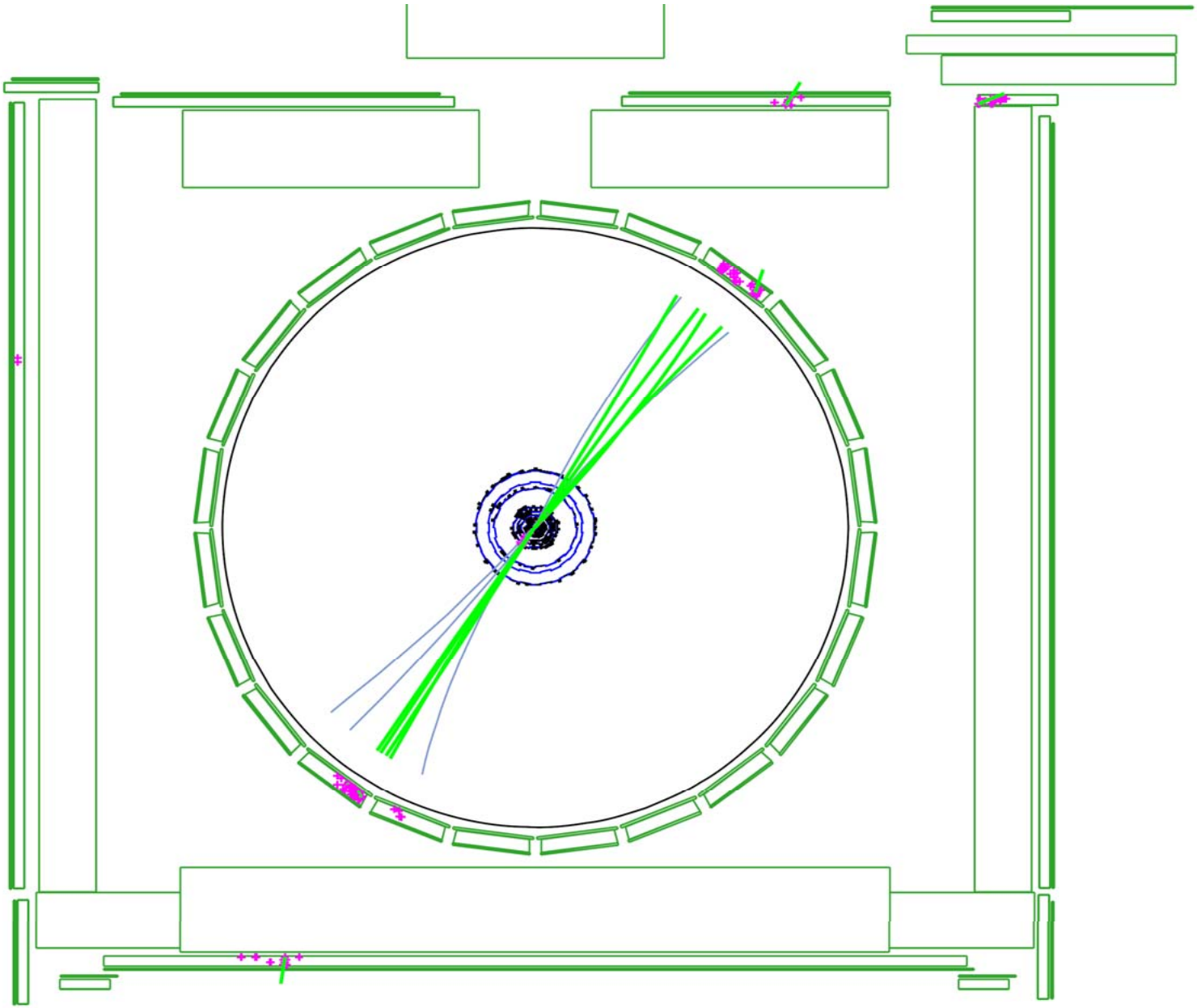

Event : 1292359 Run : 141213 EventType : DATA | Unpresc: 0,32,33,2,34,3,4,5,40,41,10,11,43,13,16,17,19,21,23,25,26,


Et = 141.70 Ge

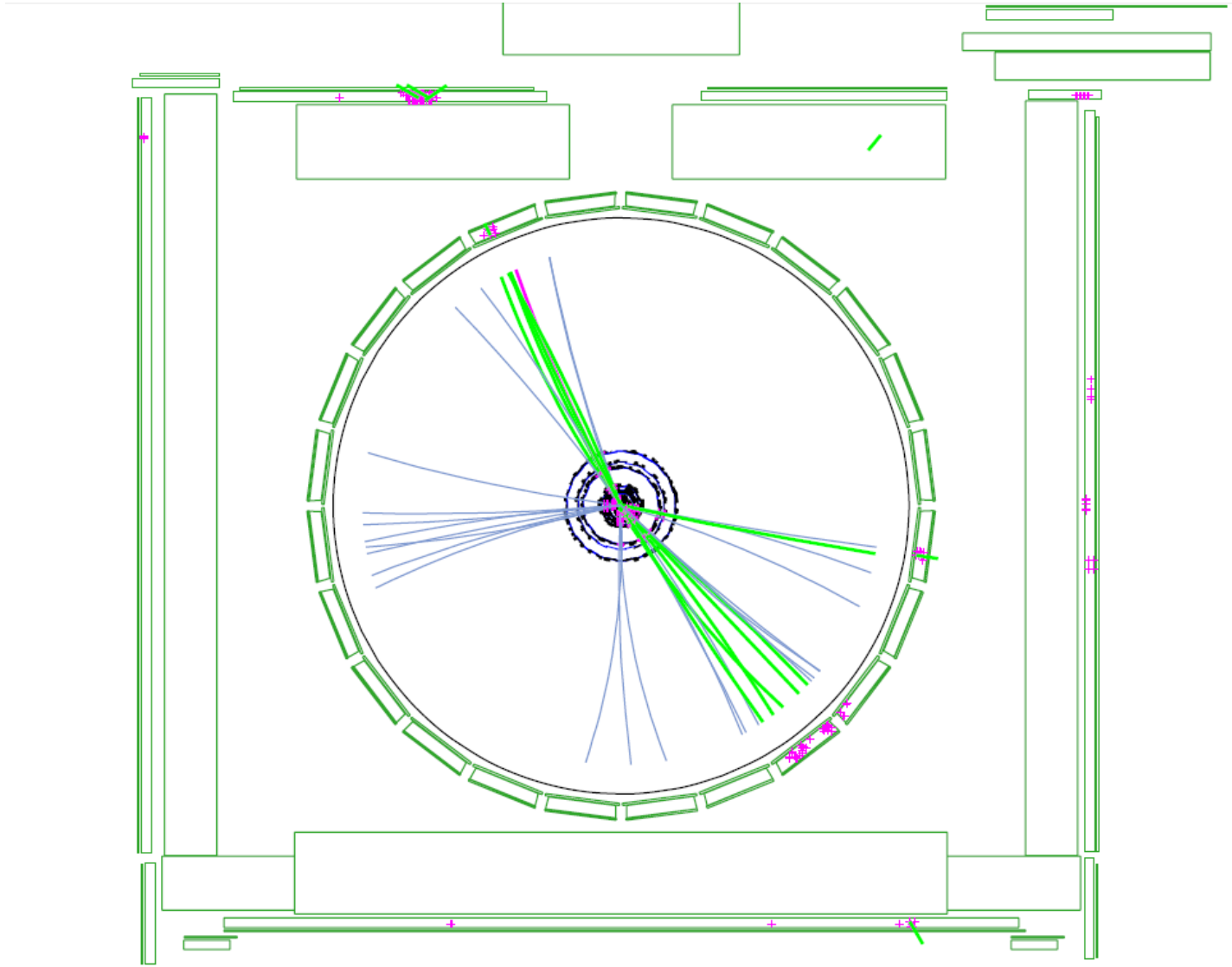

DATA Event : 3008617 Run : 155130 | Prescaled: 0,1,11,19,24,25,26,28,36,37,40,41,48,49,51,56,57,58,60,61
Unprescaled: 0,1,11,13,15,17,19,21,23,24,25,26,28,33,36,37,39,40,41,43,48,49,50,51,56,57,58,60,61

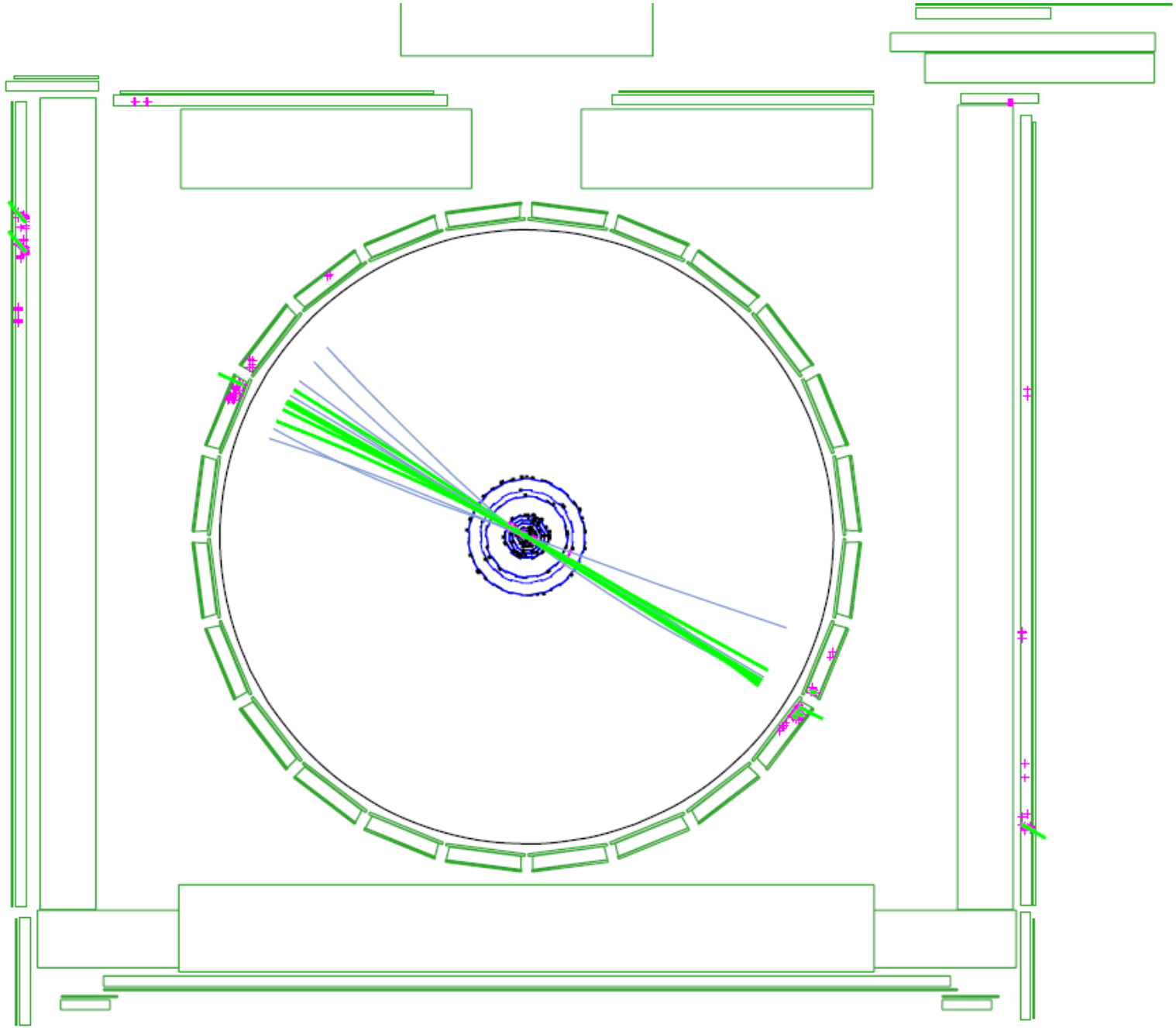

Et = 282.52 GeV

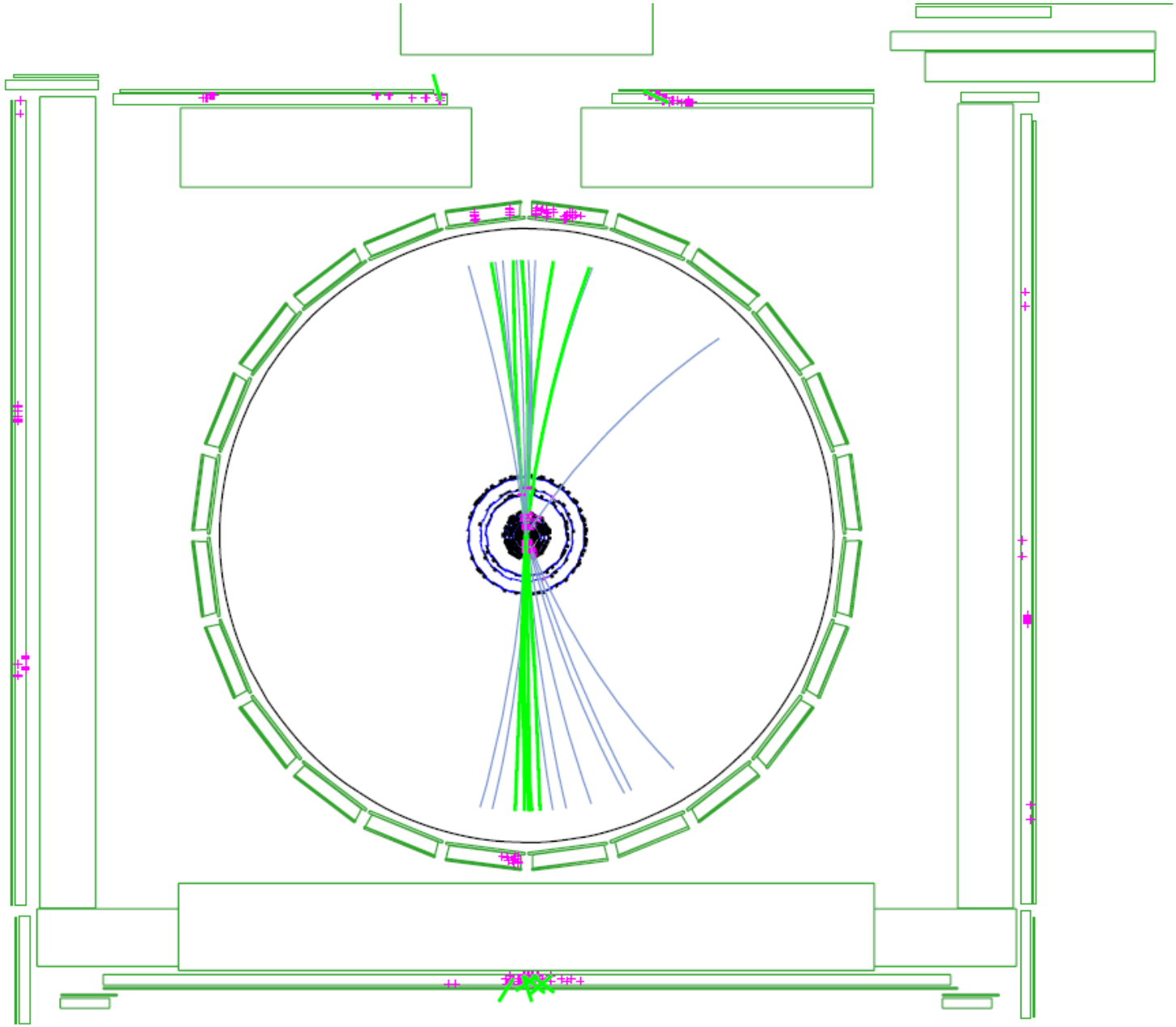
1



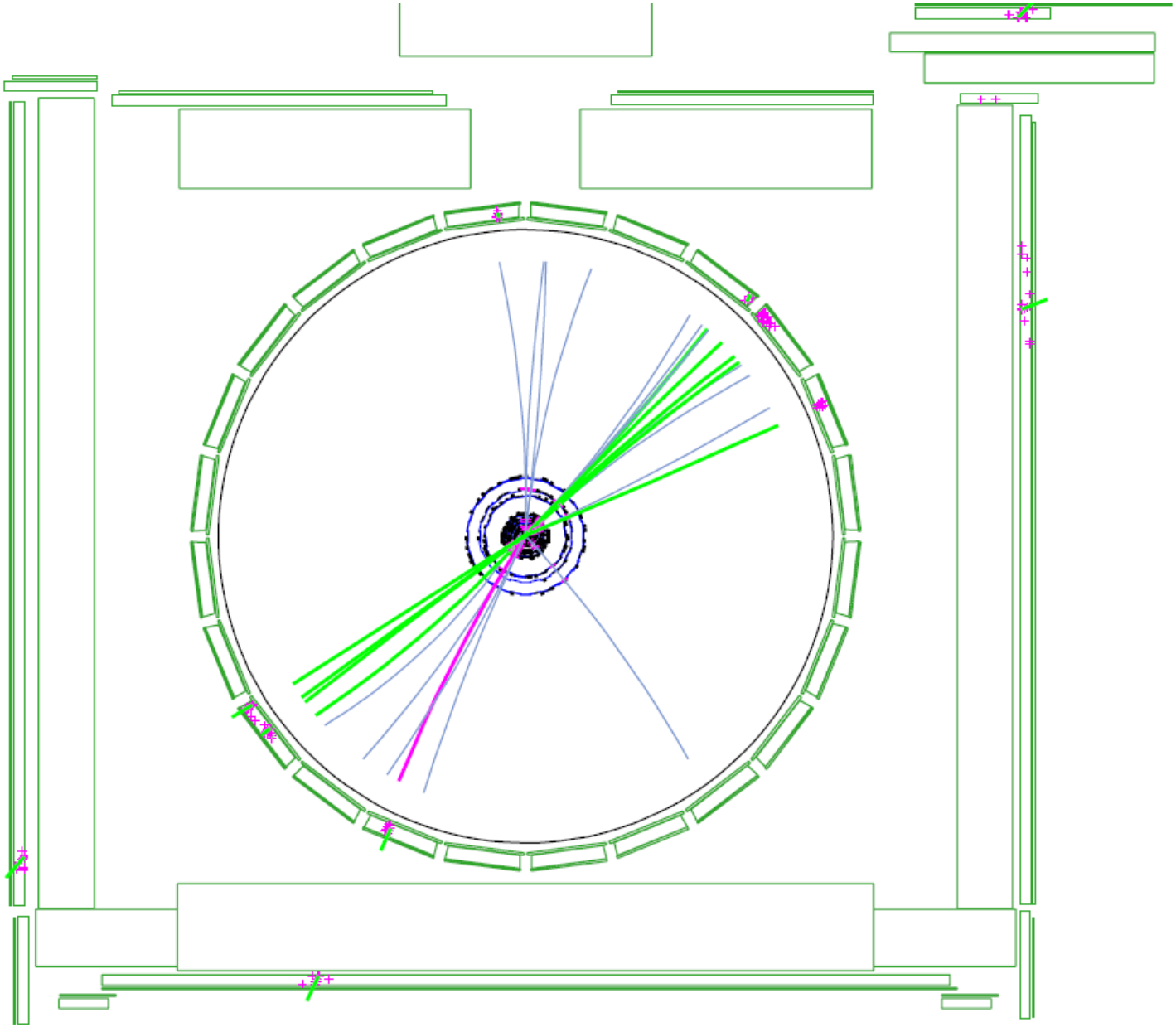
2



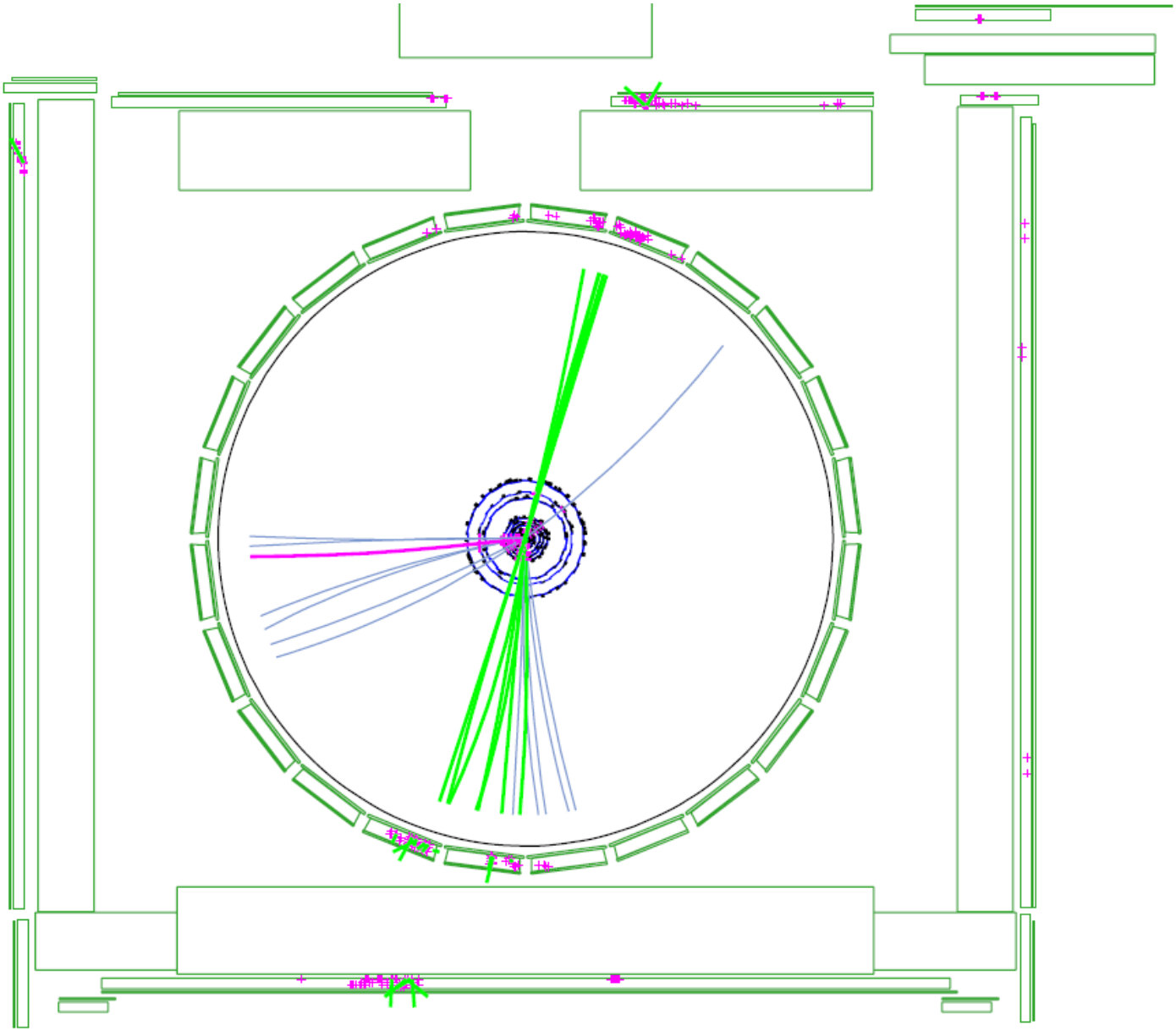


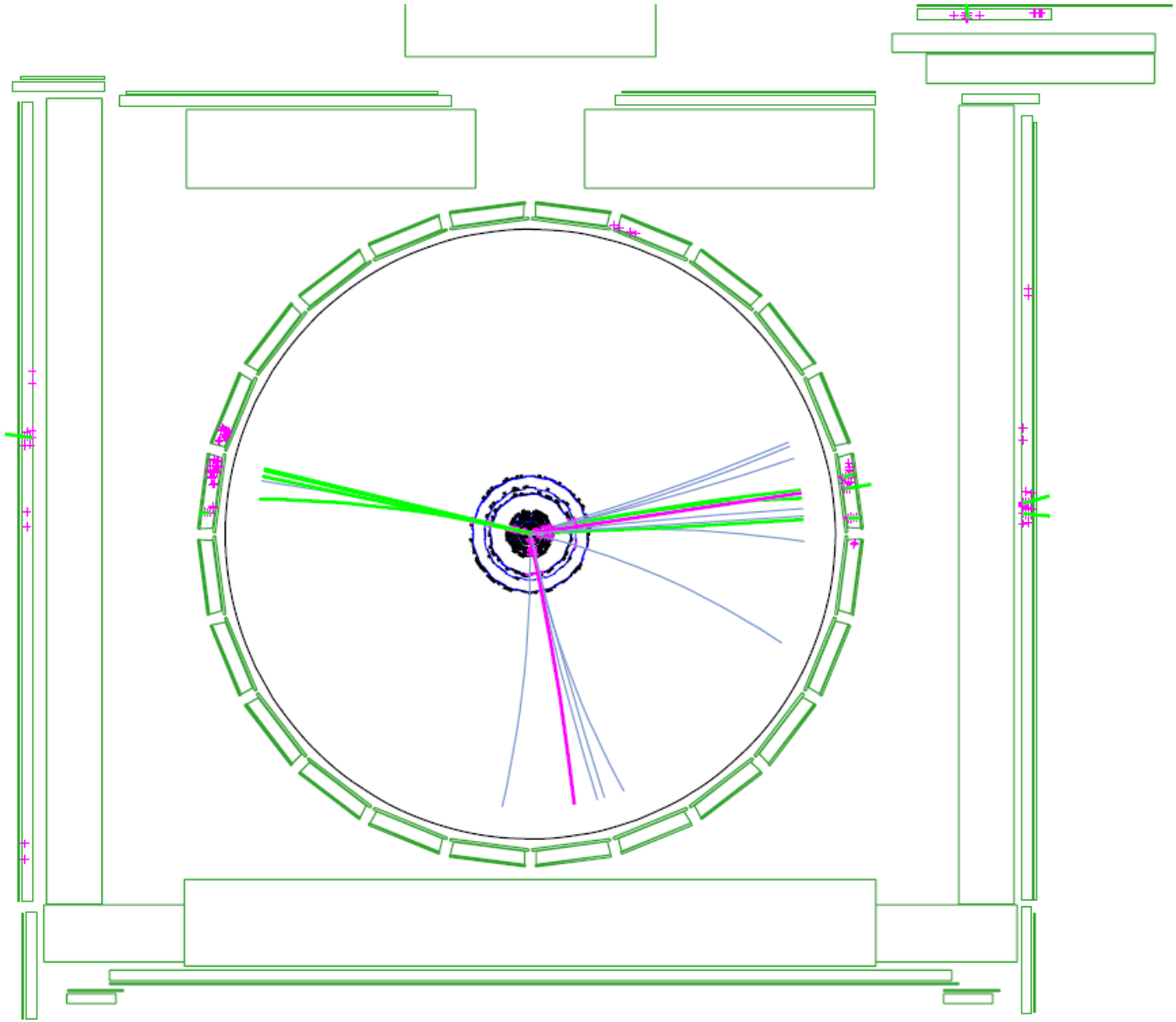


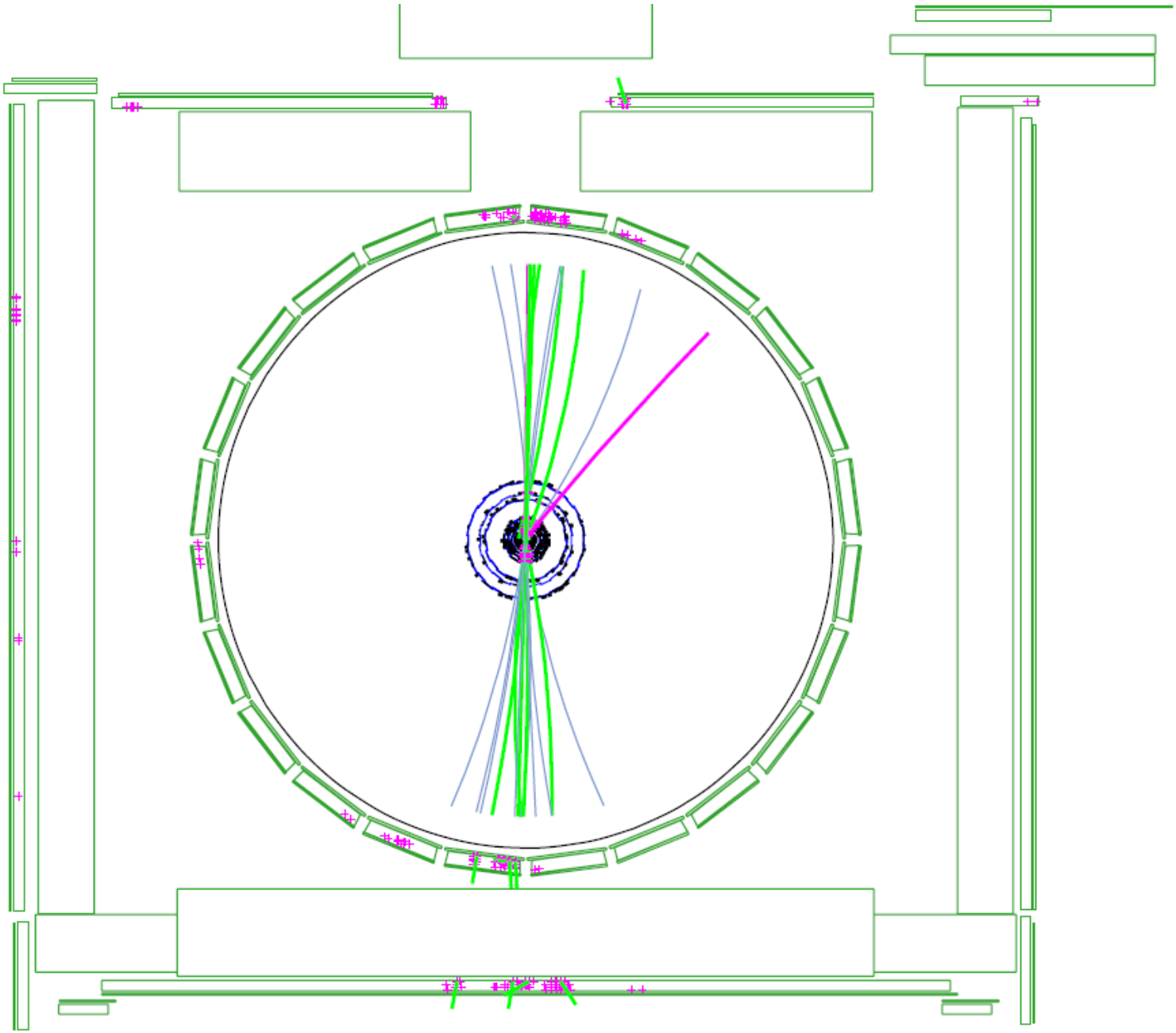
5

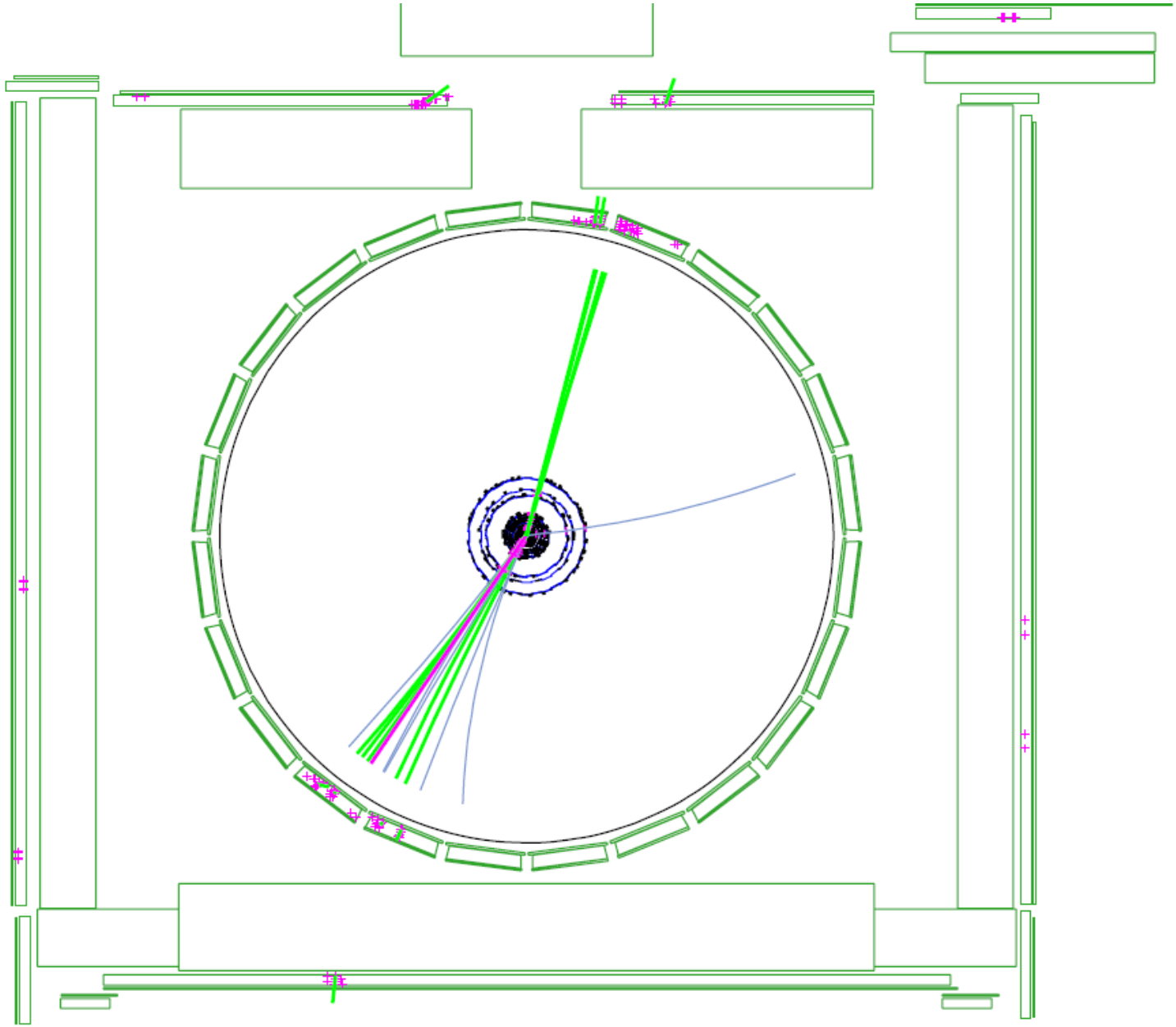


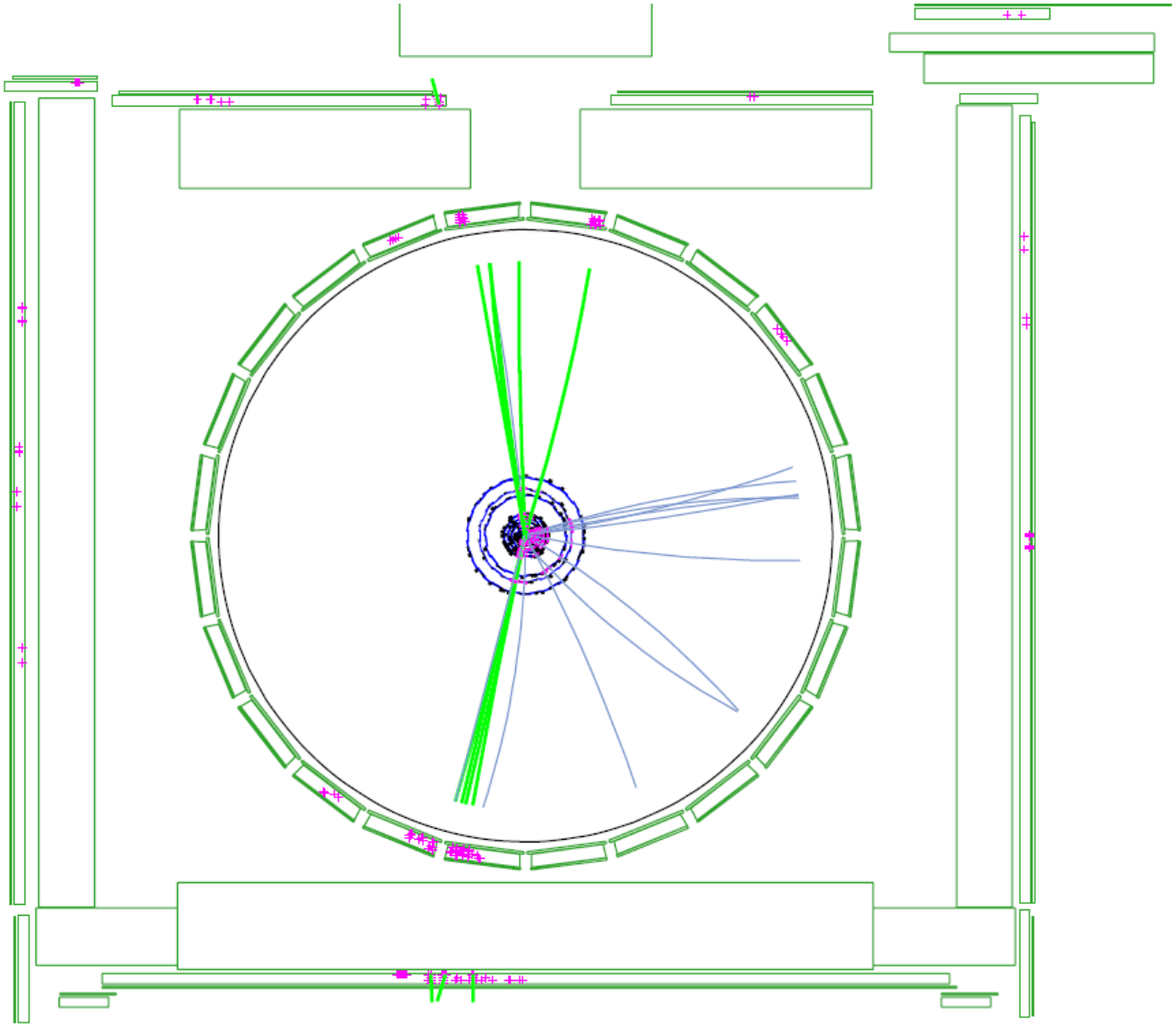
6

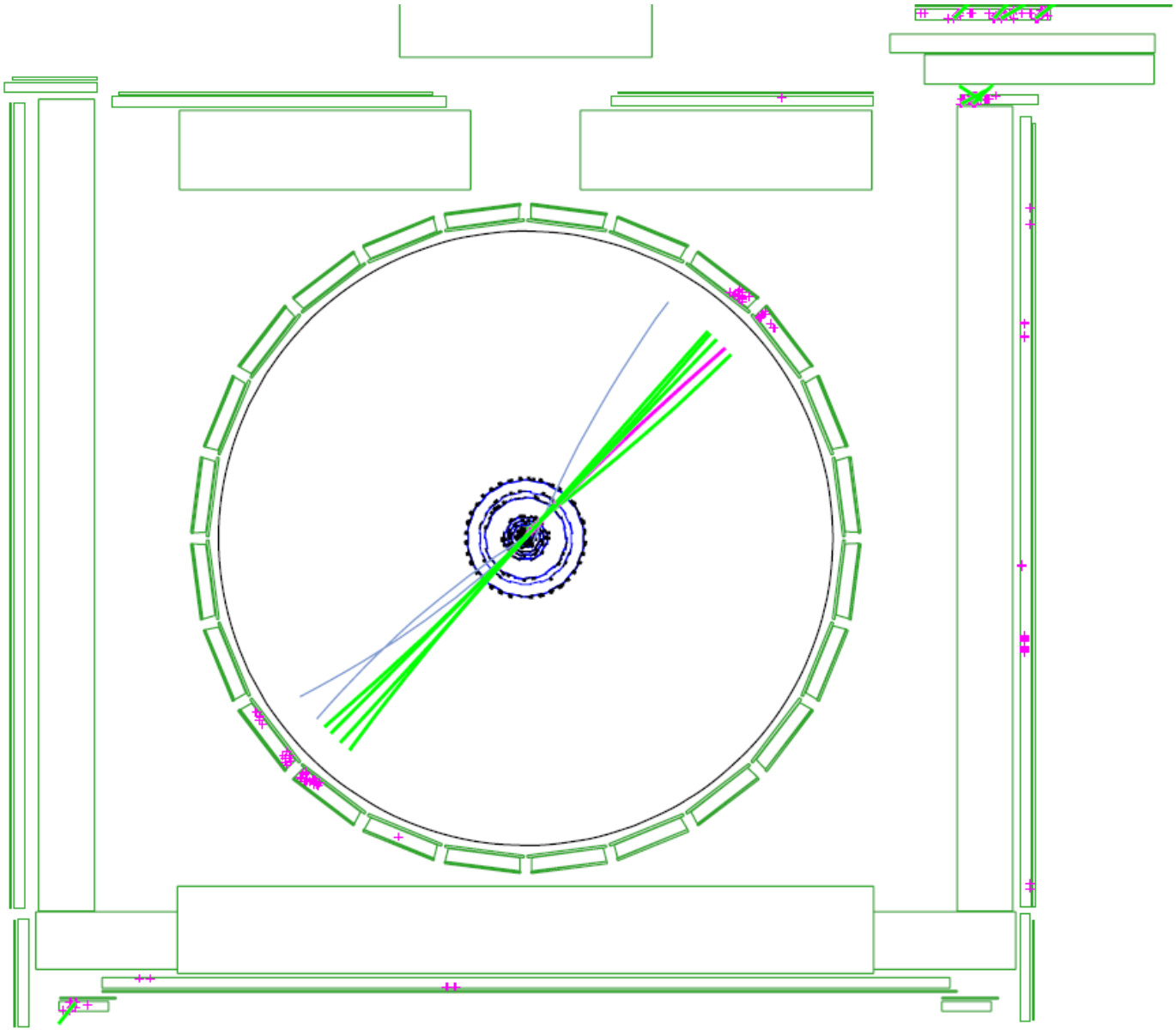


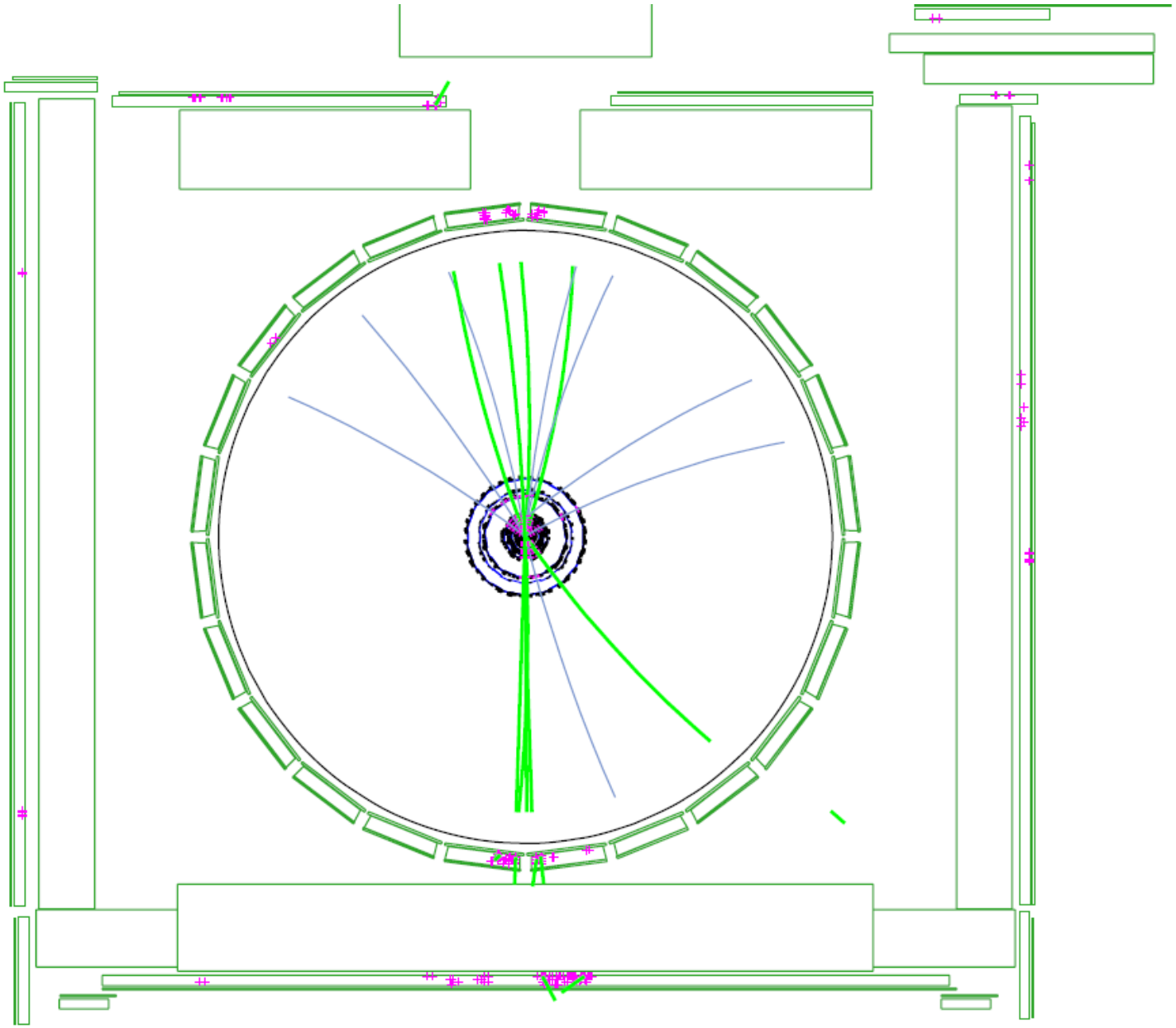


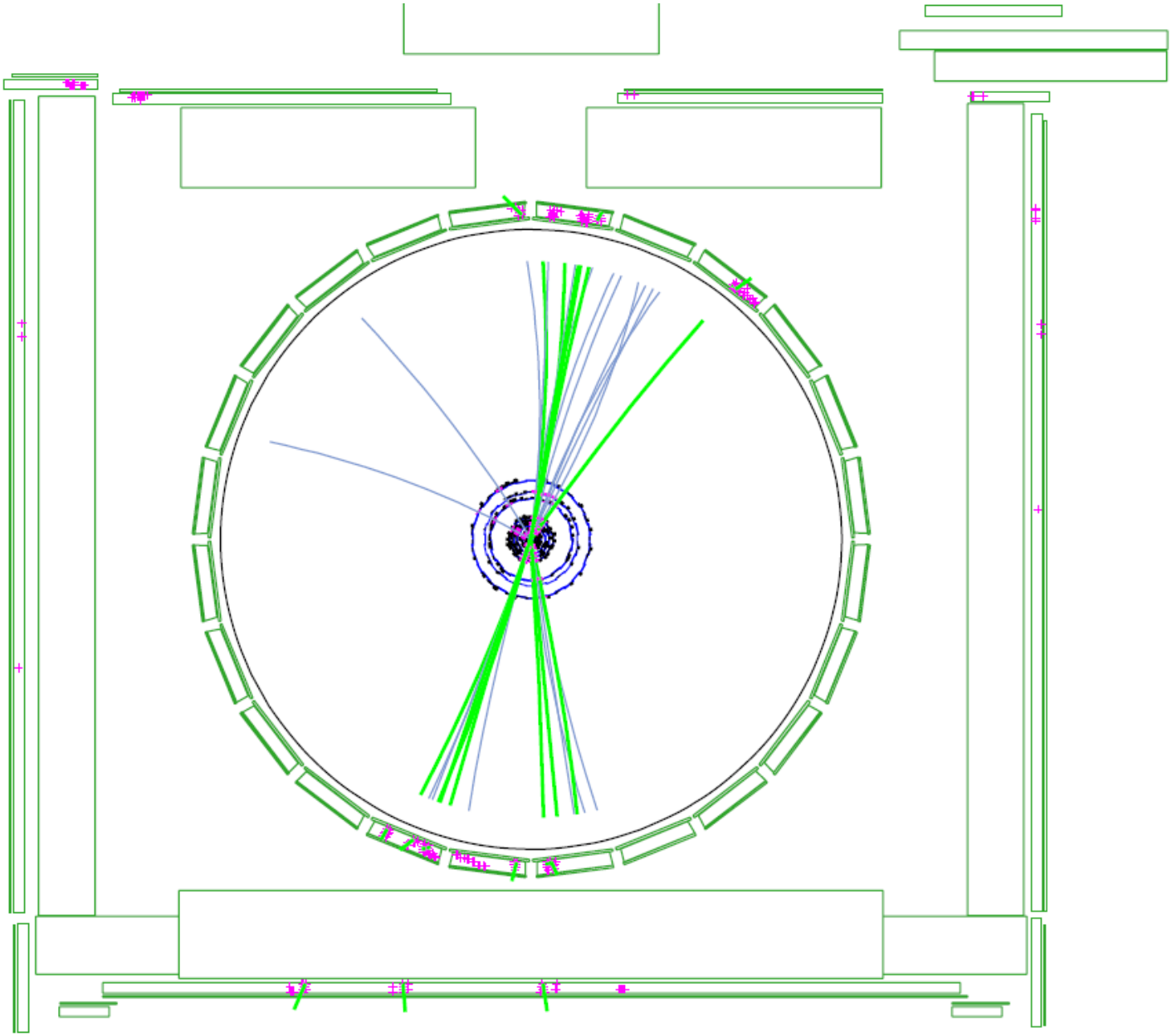


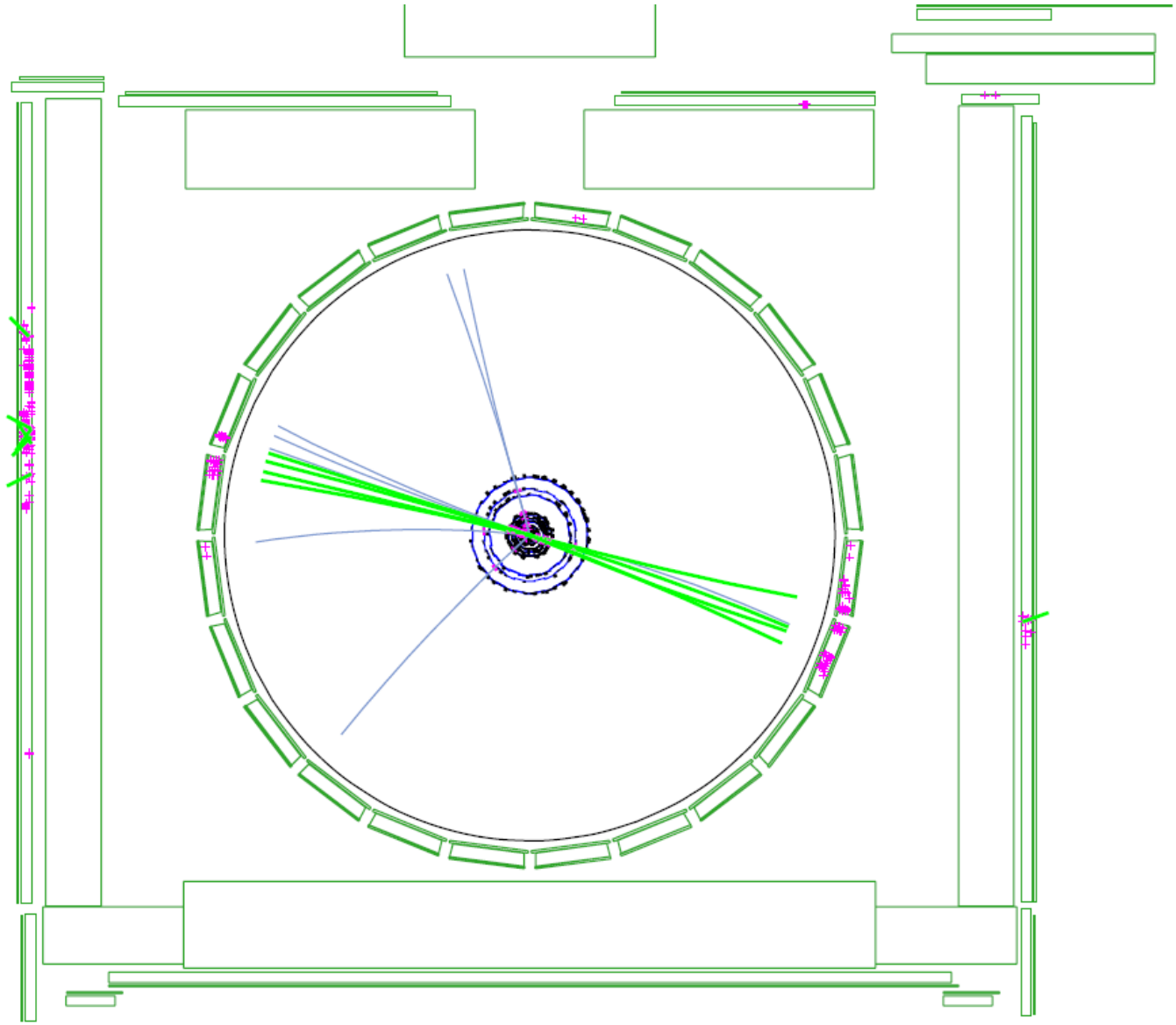


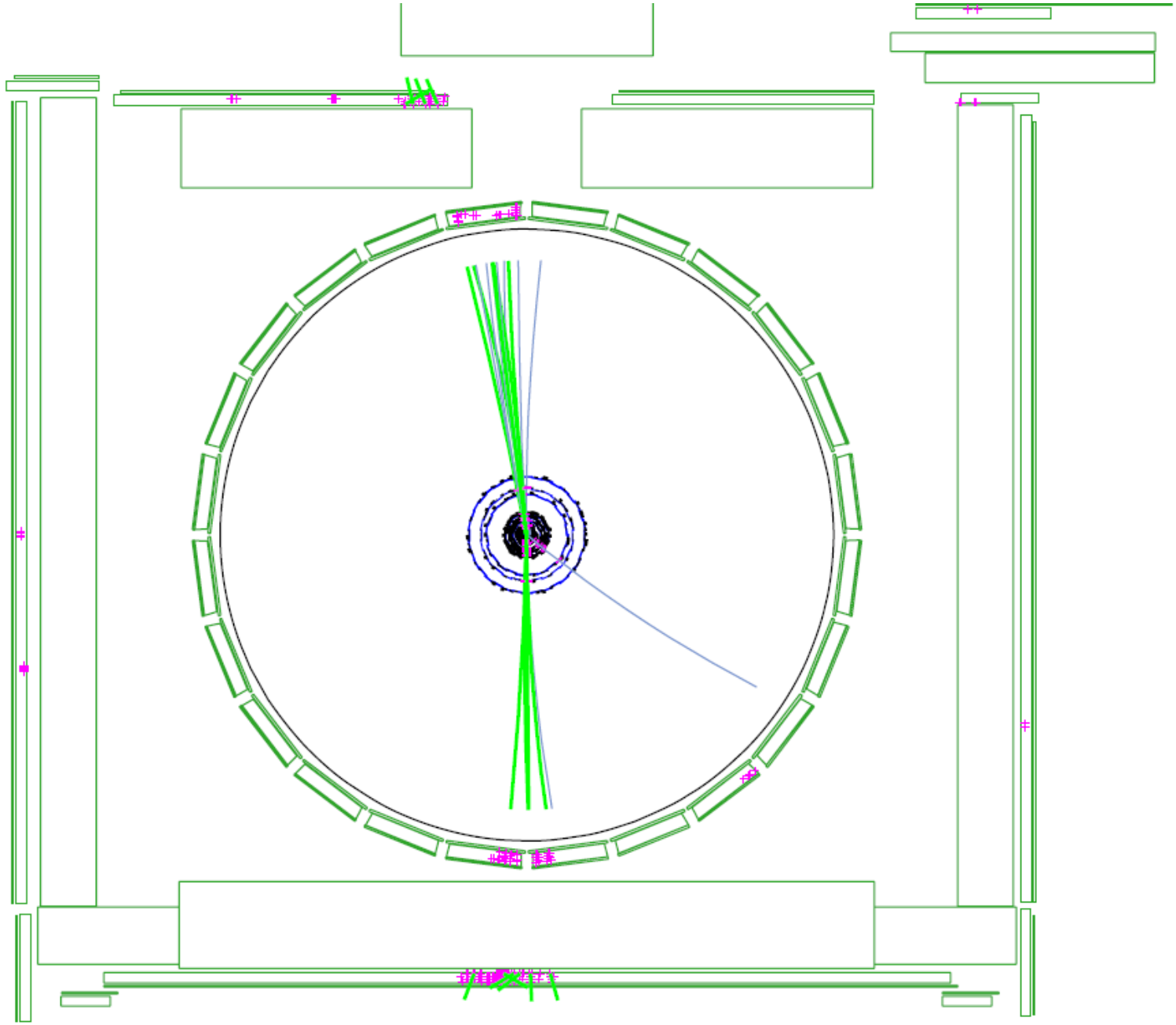


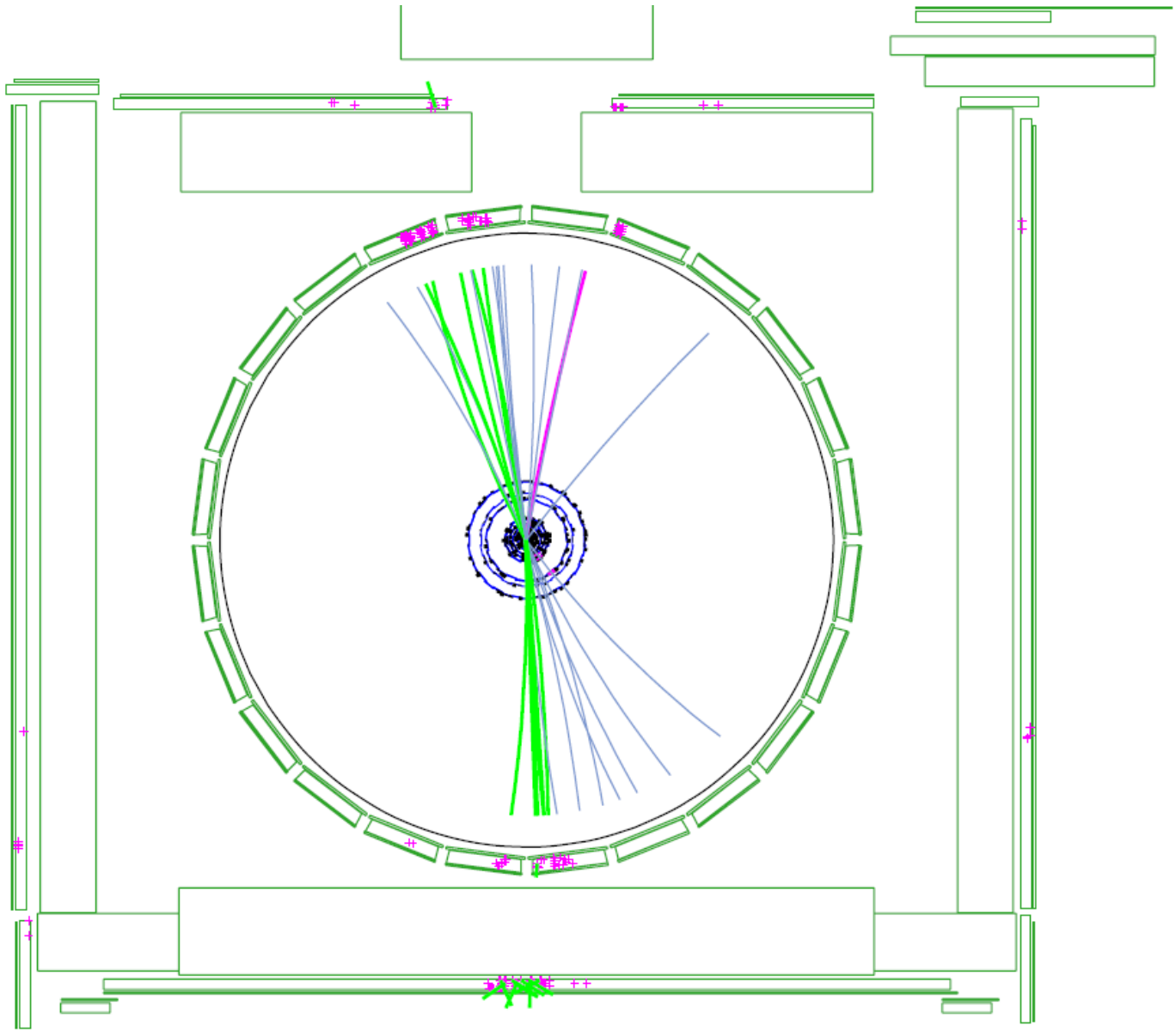


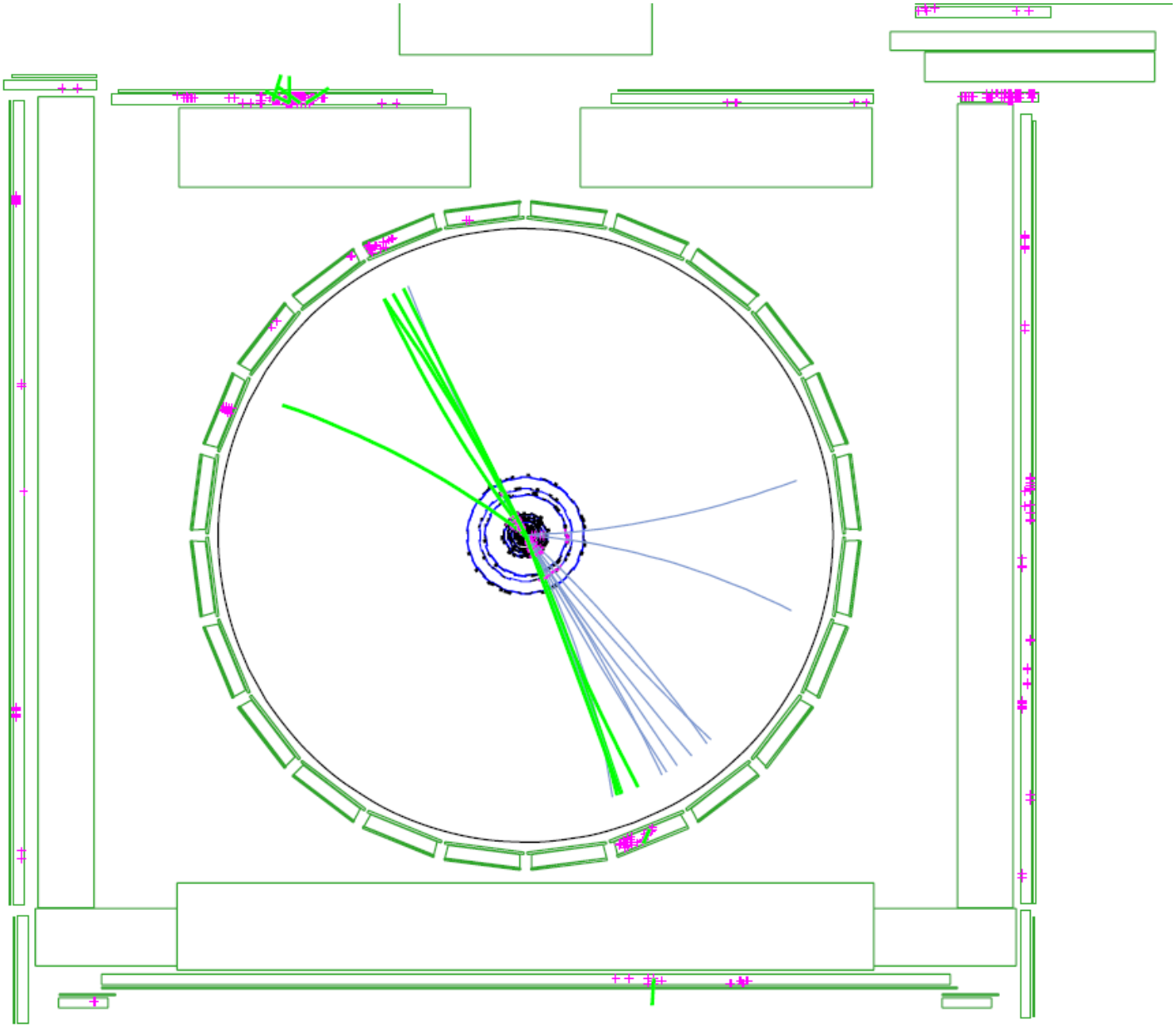


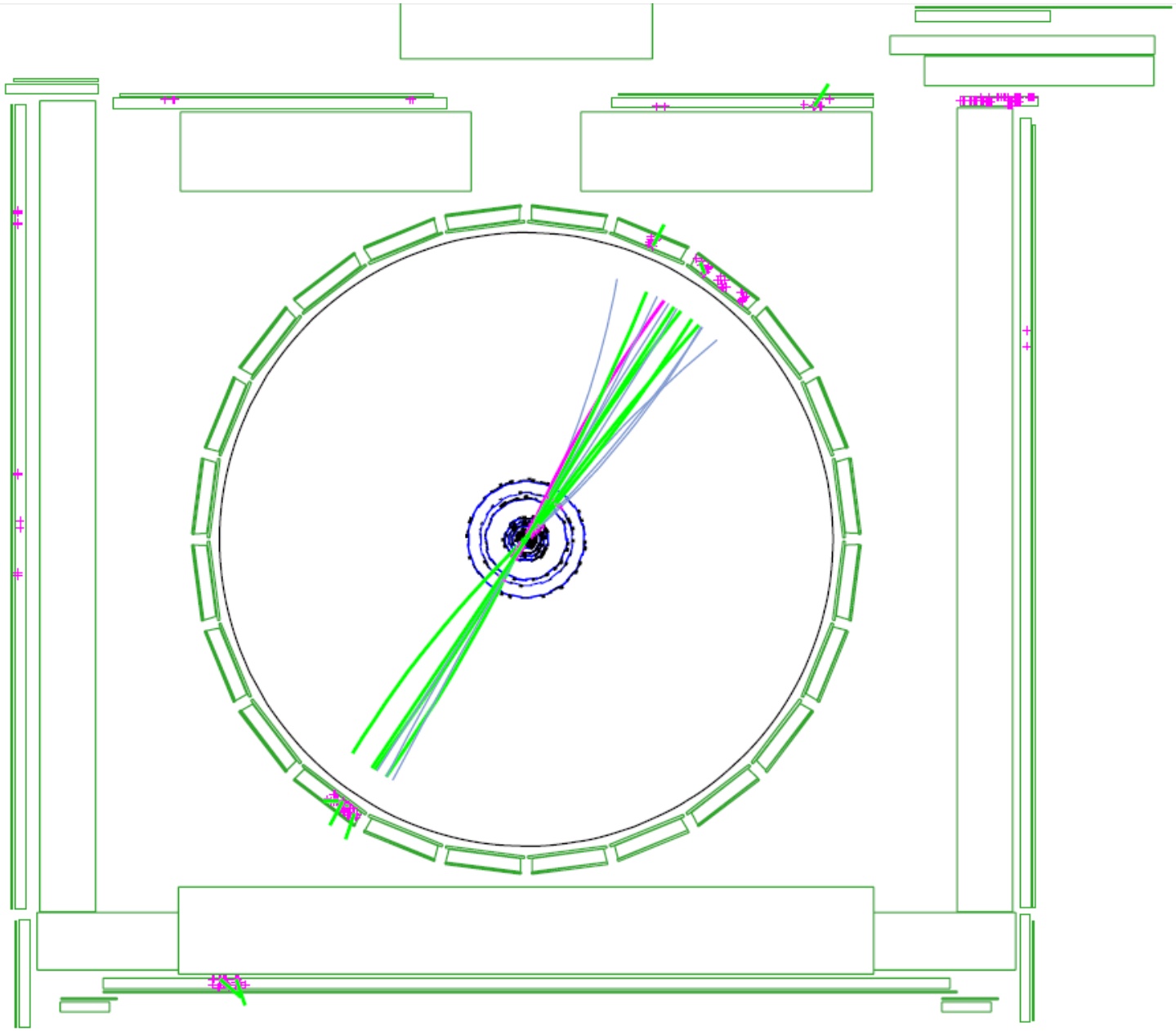


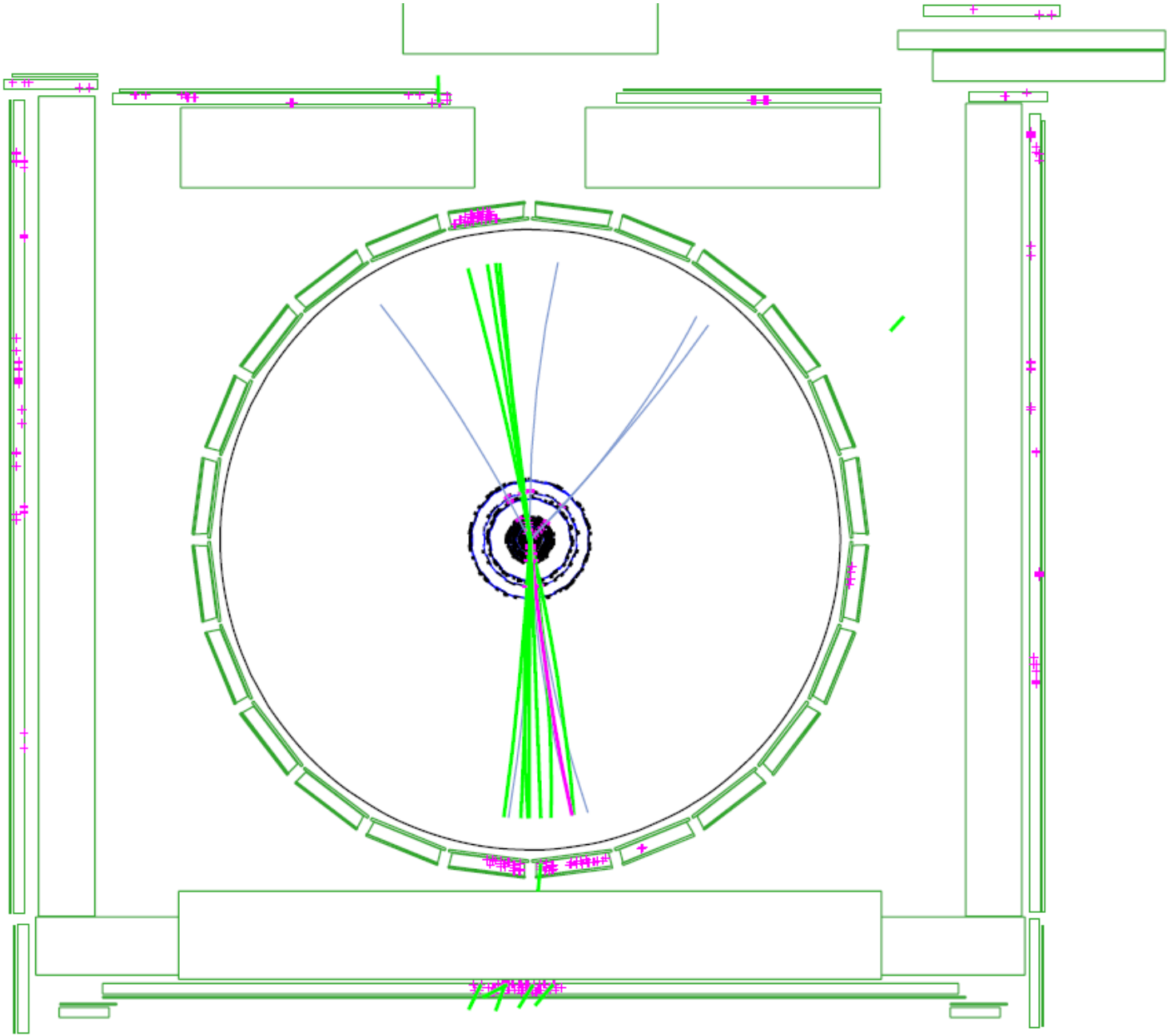


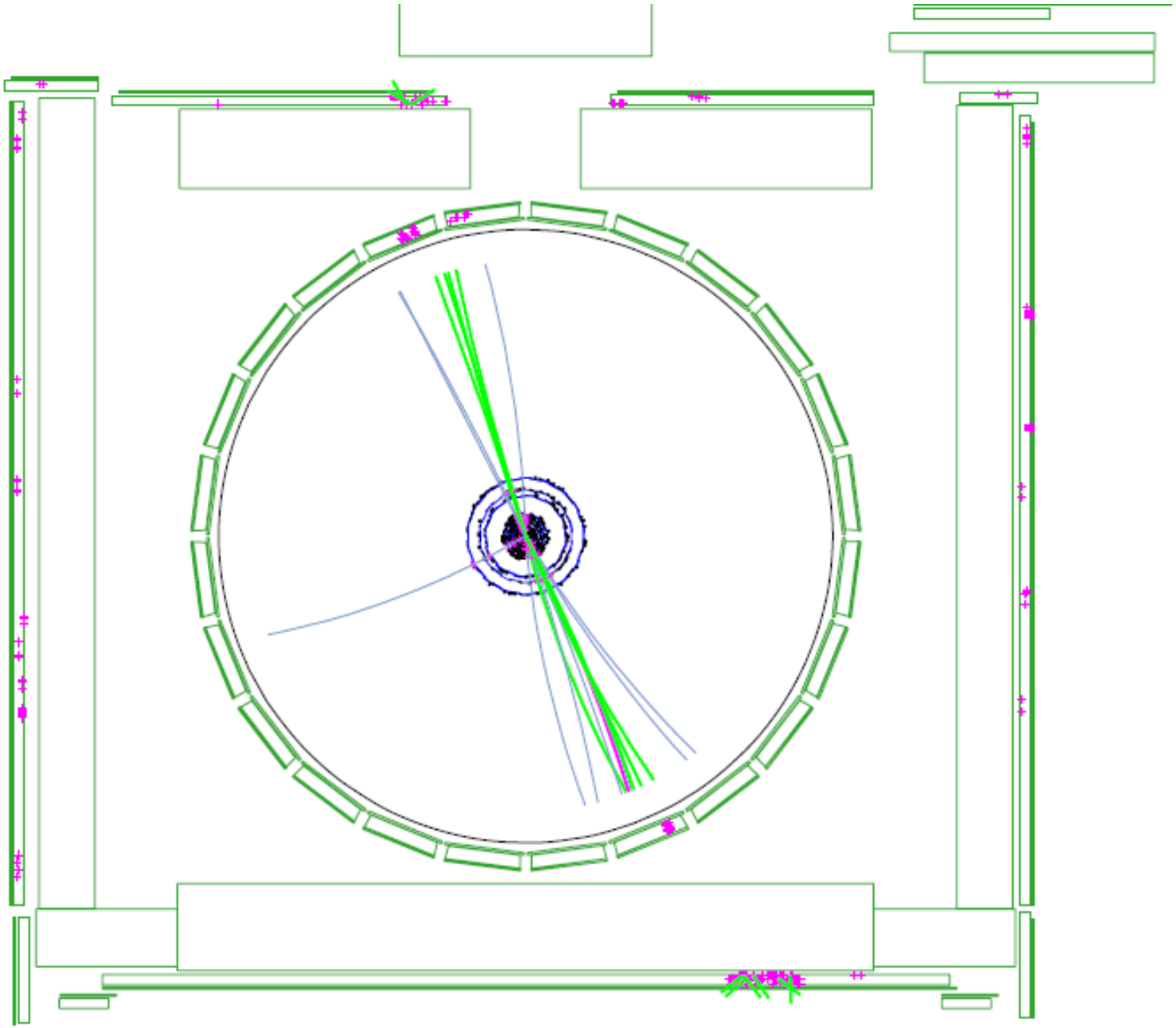


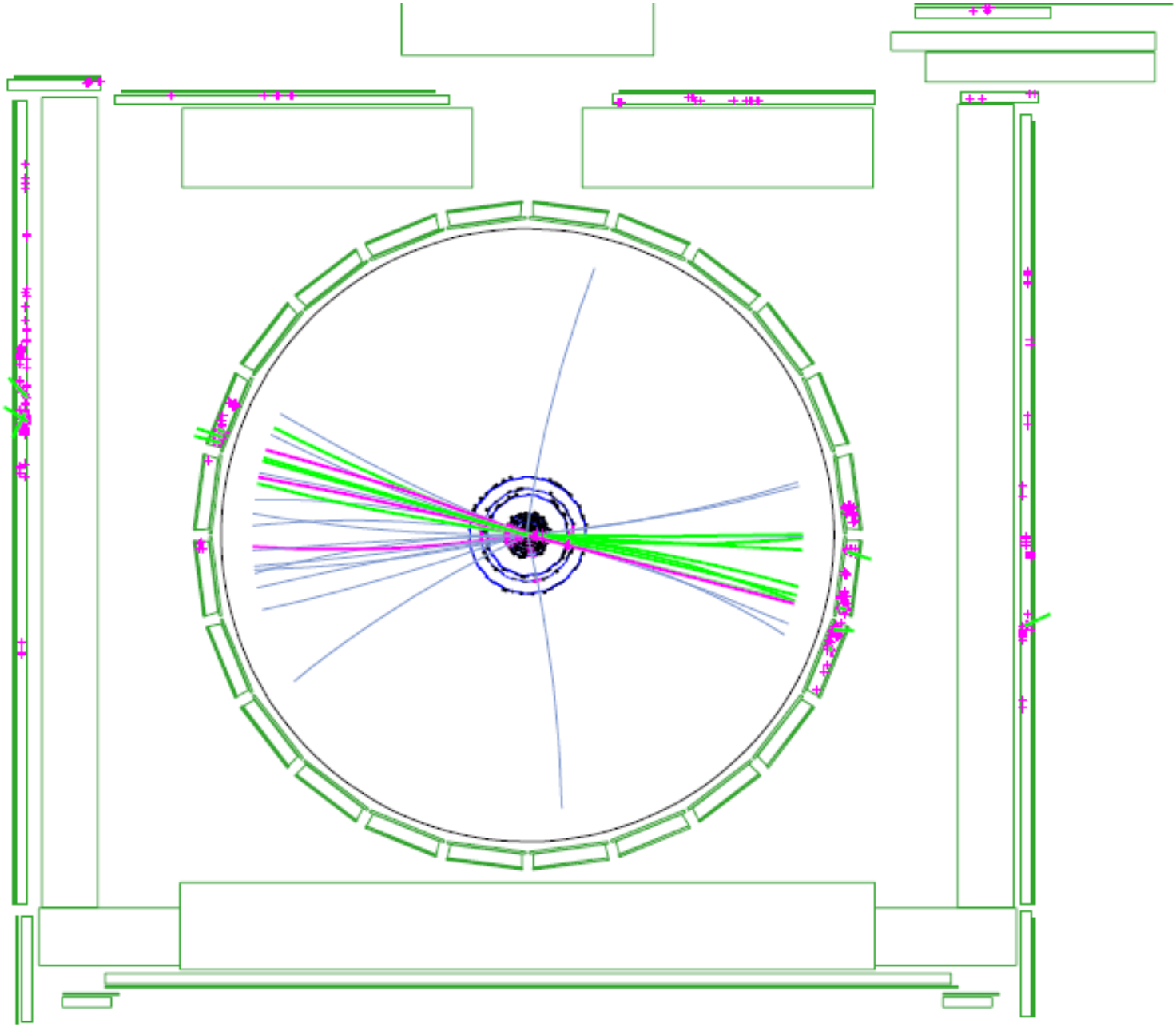


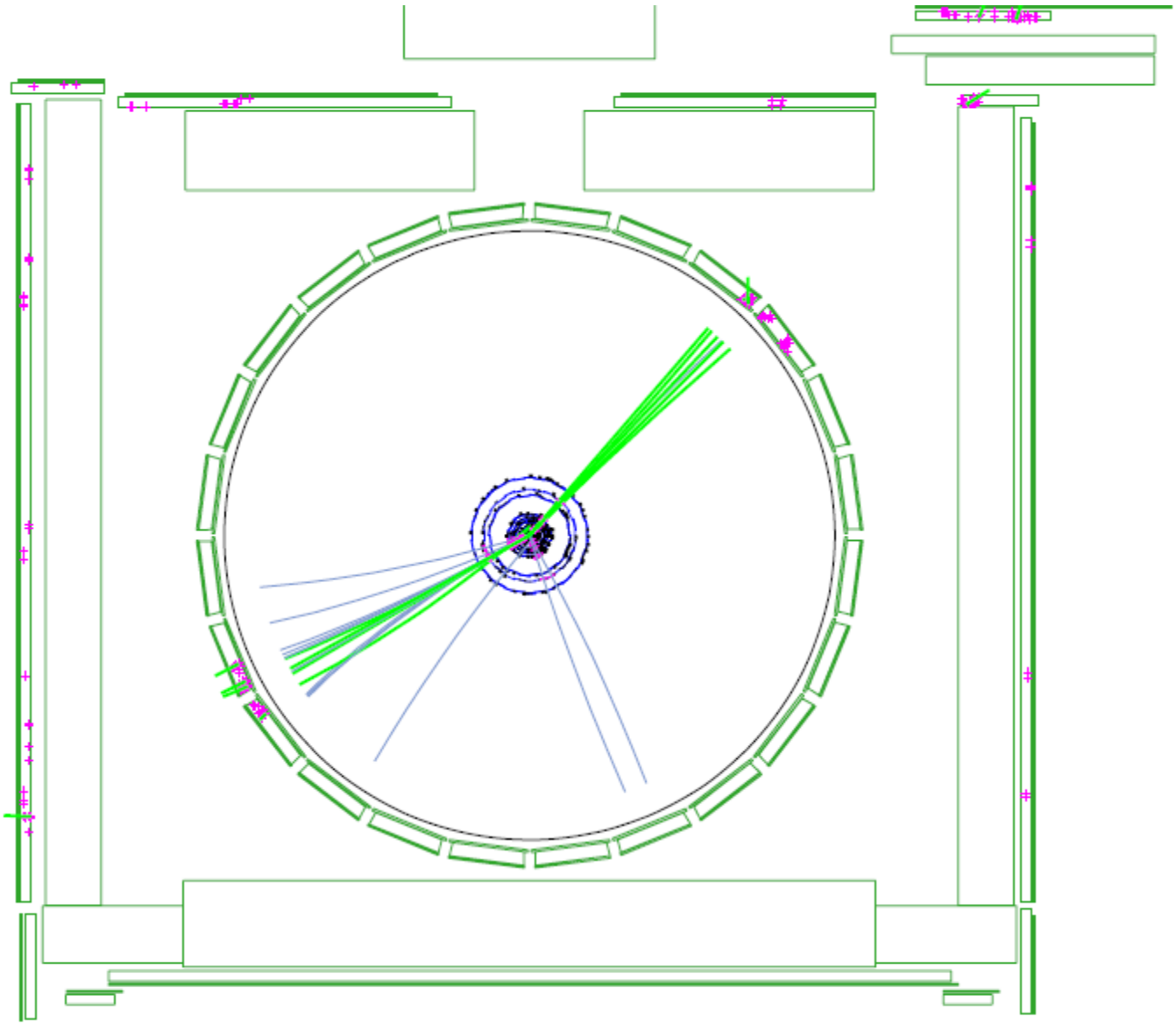


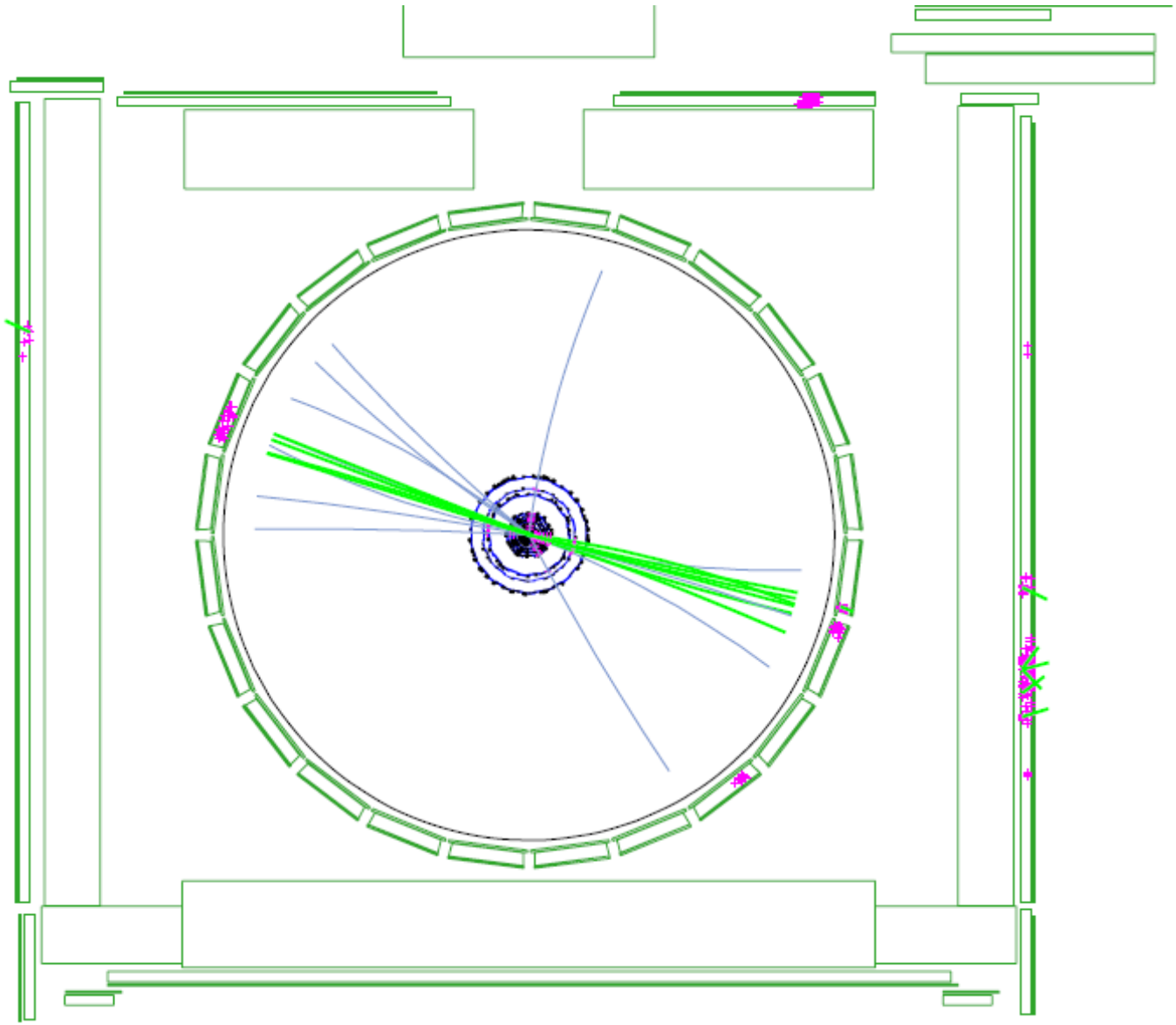


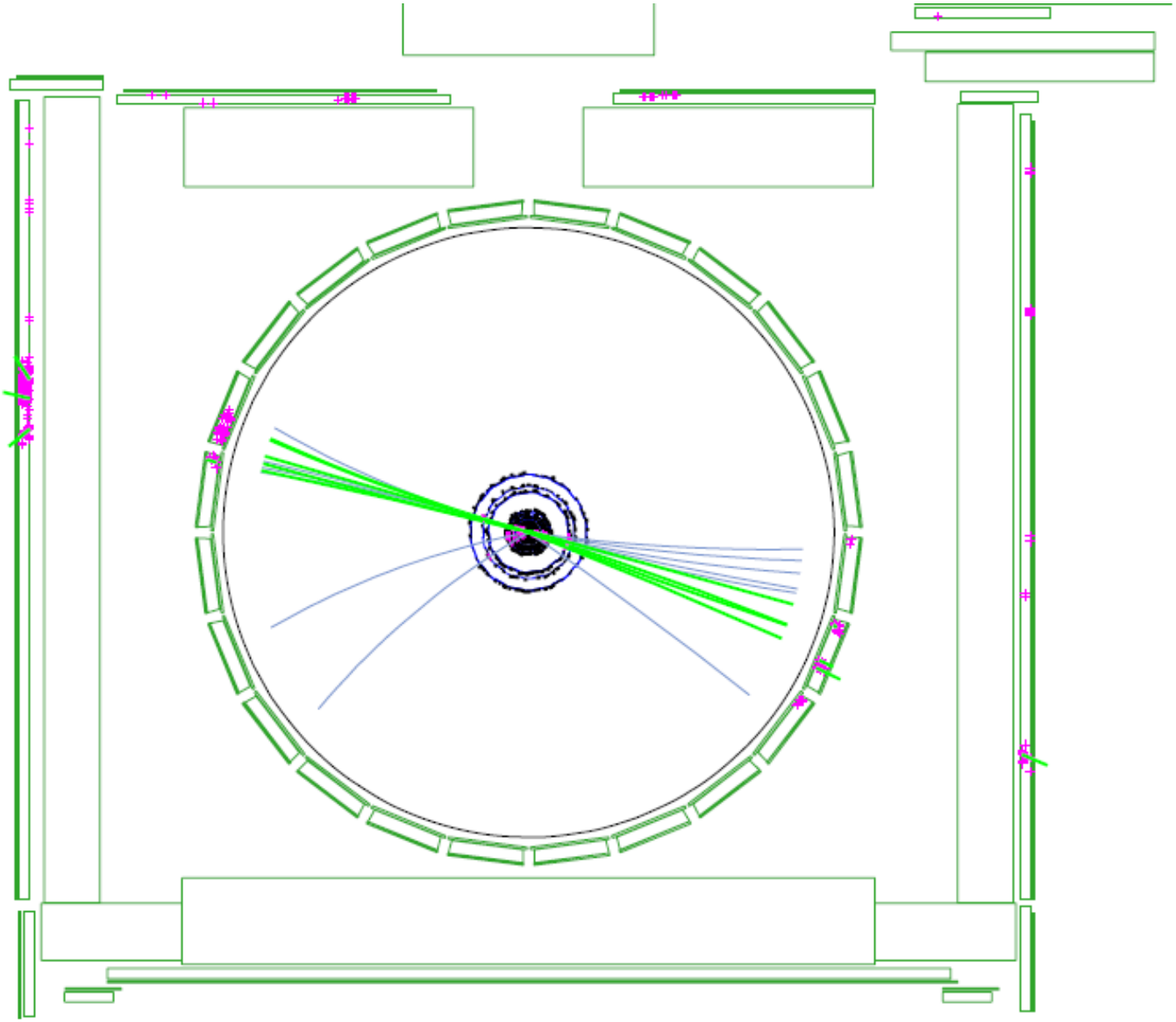












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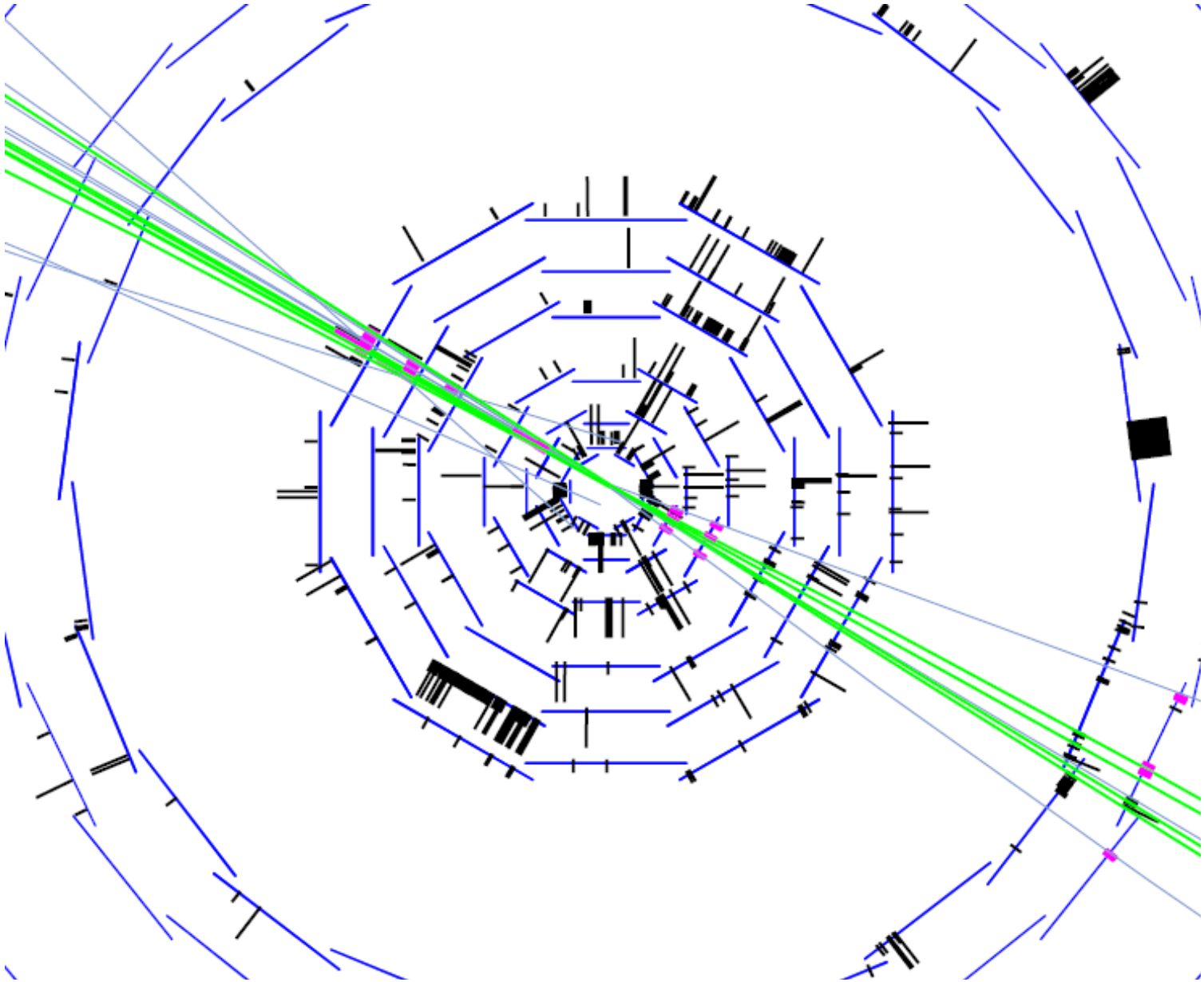
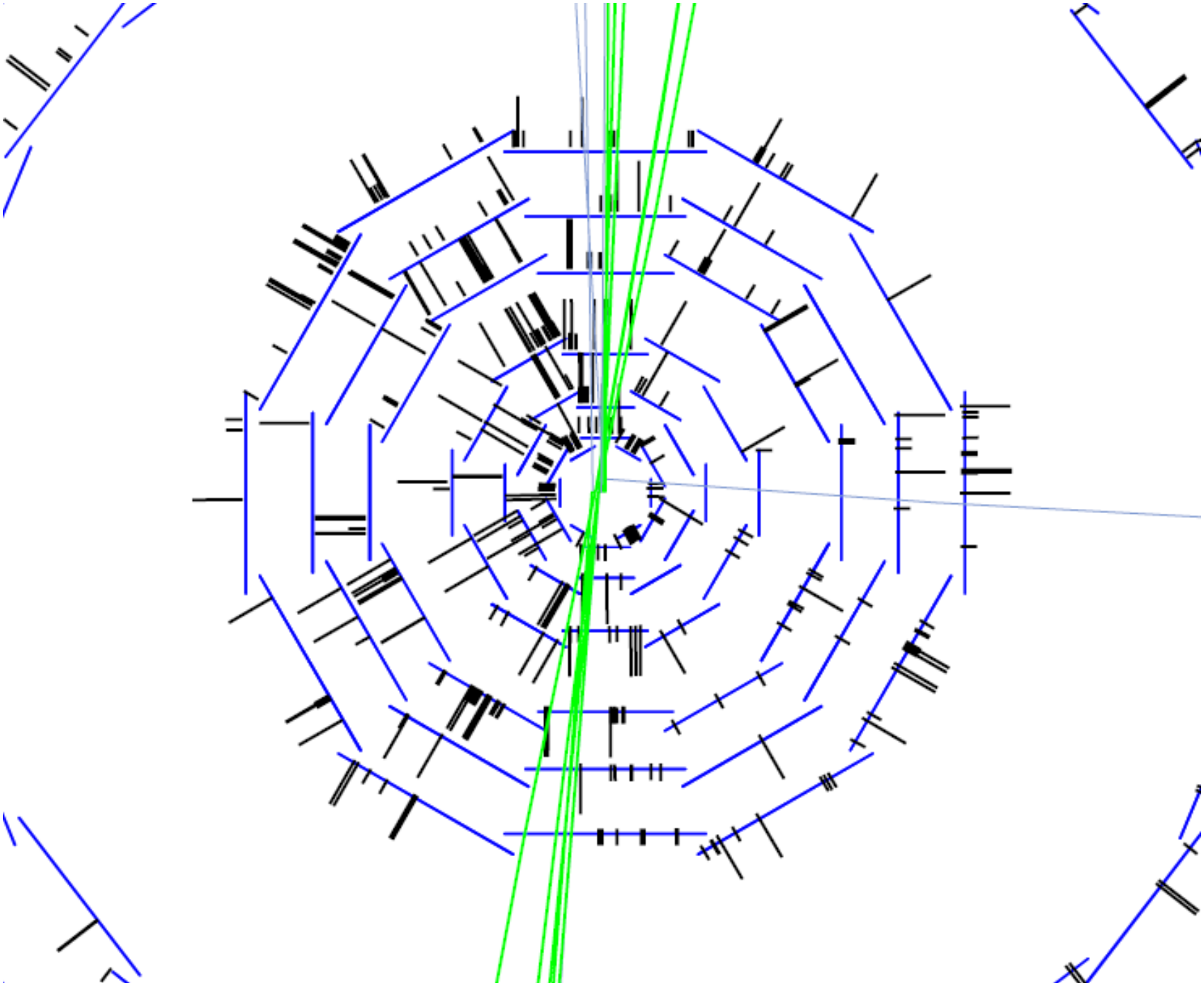
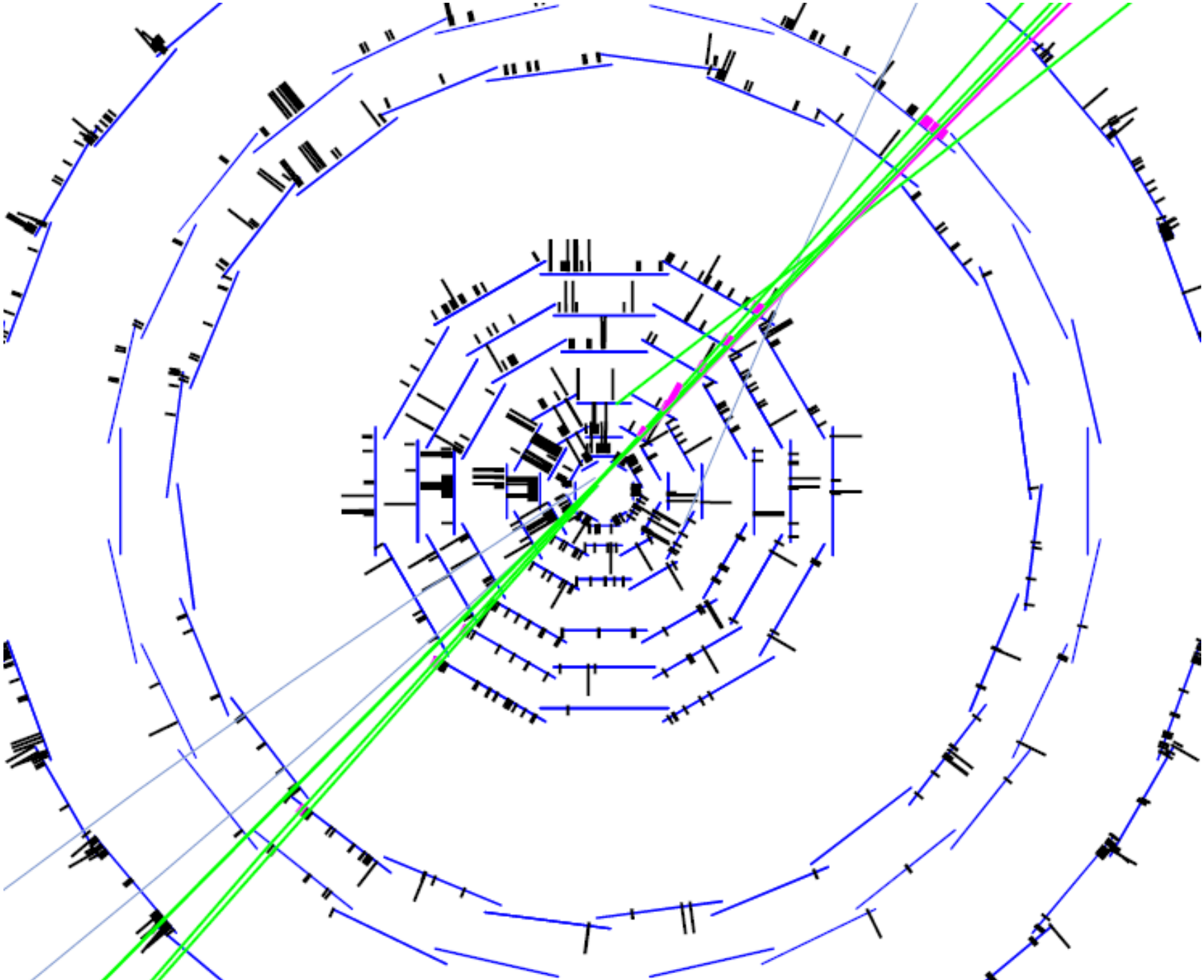
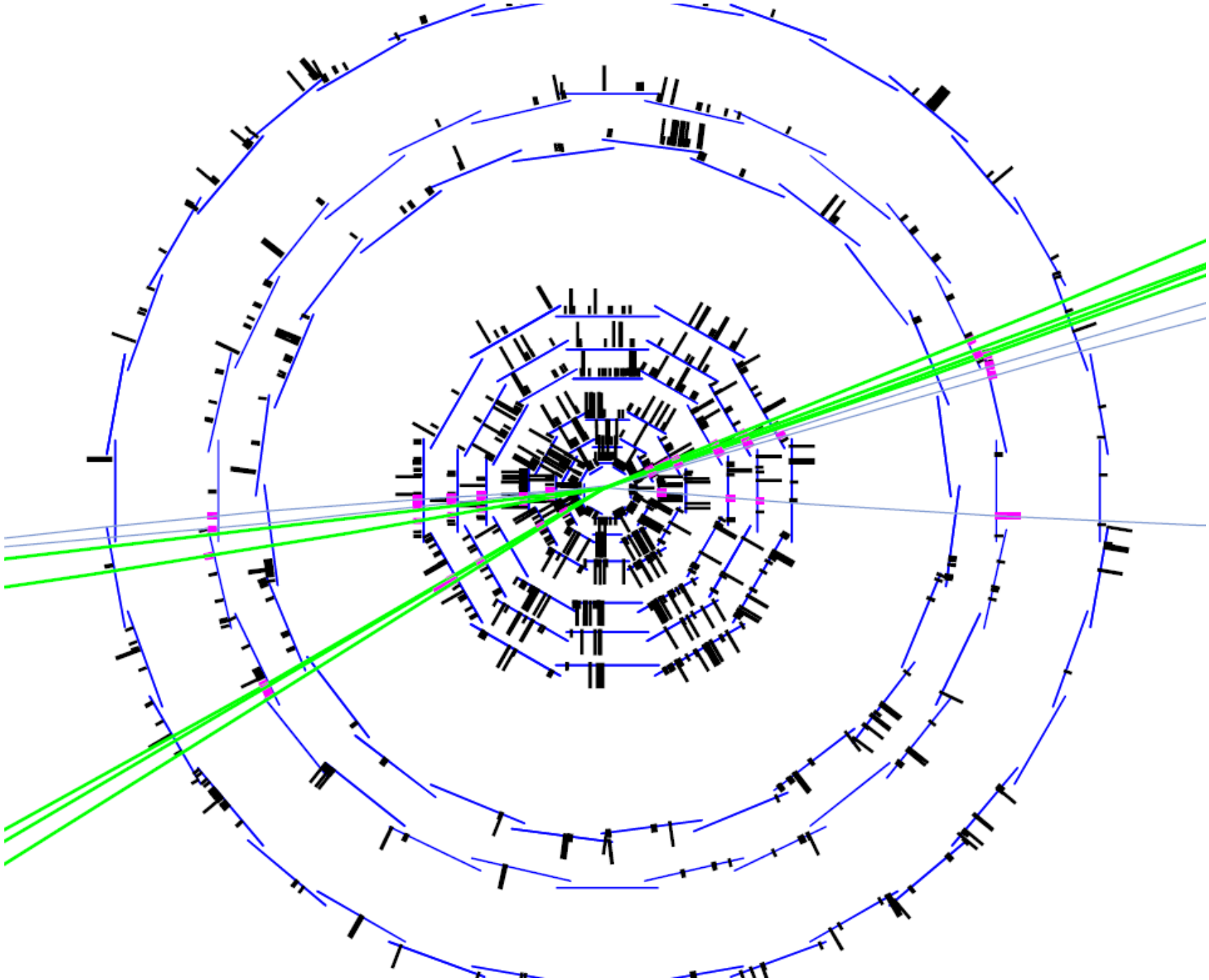
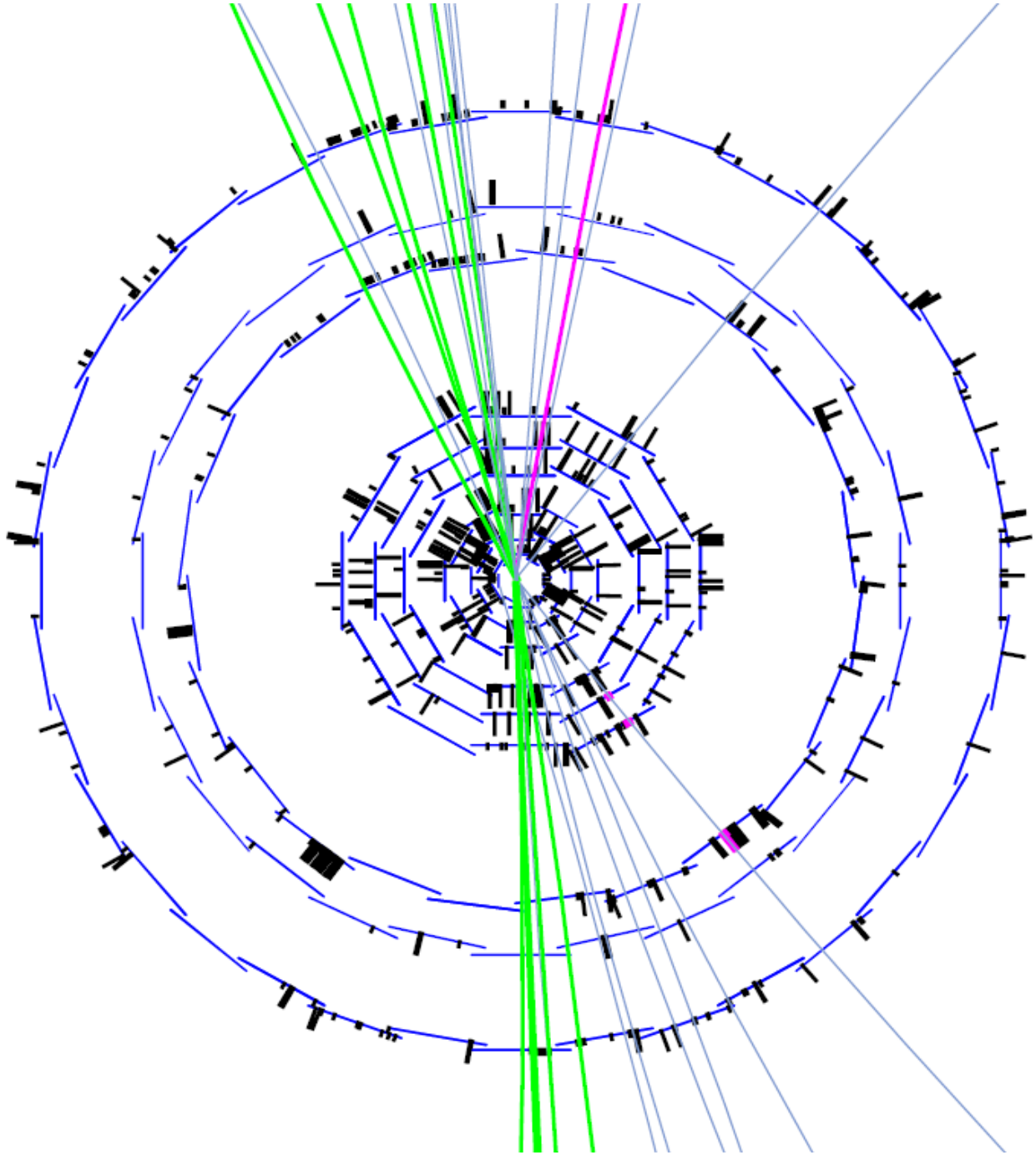
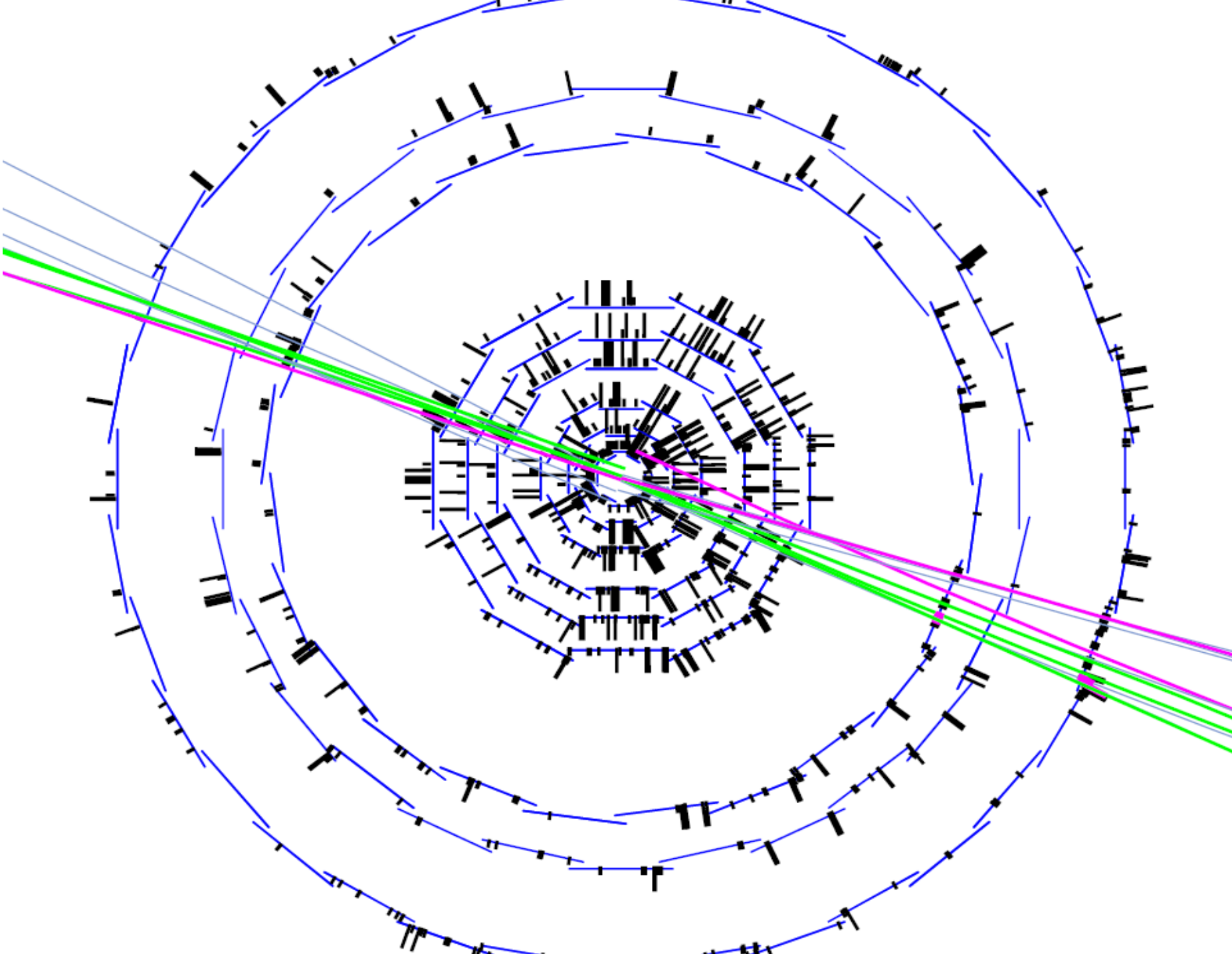


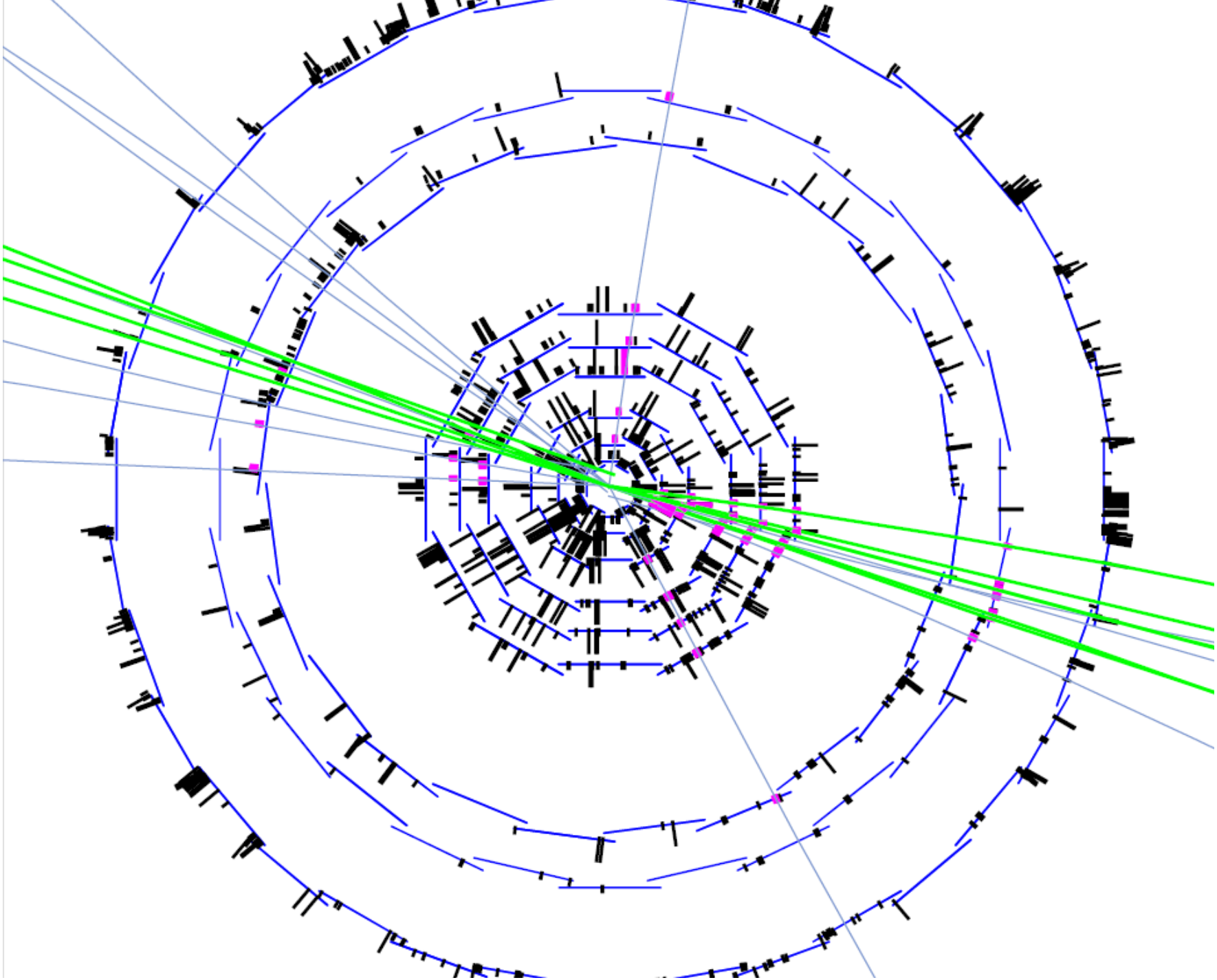


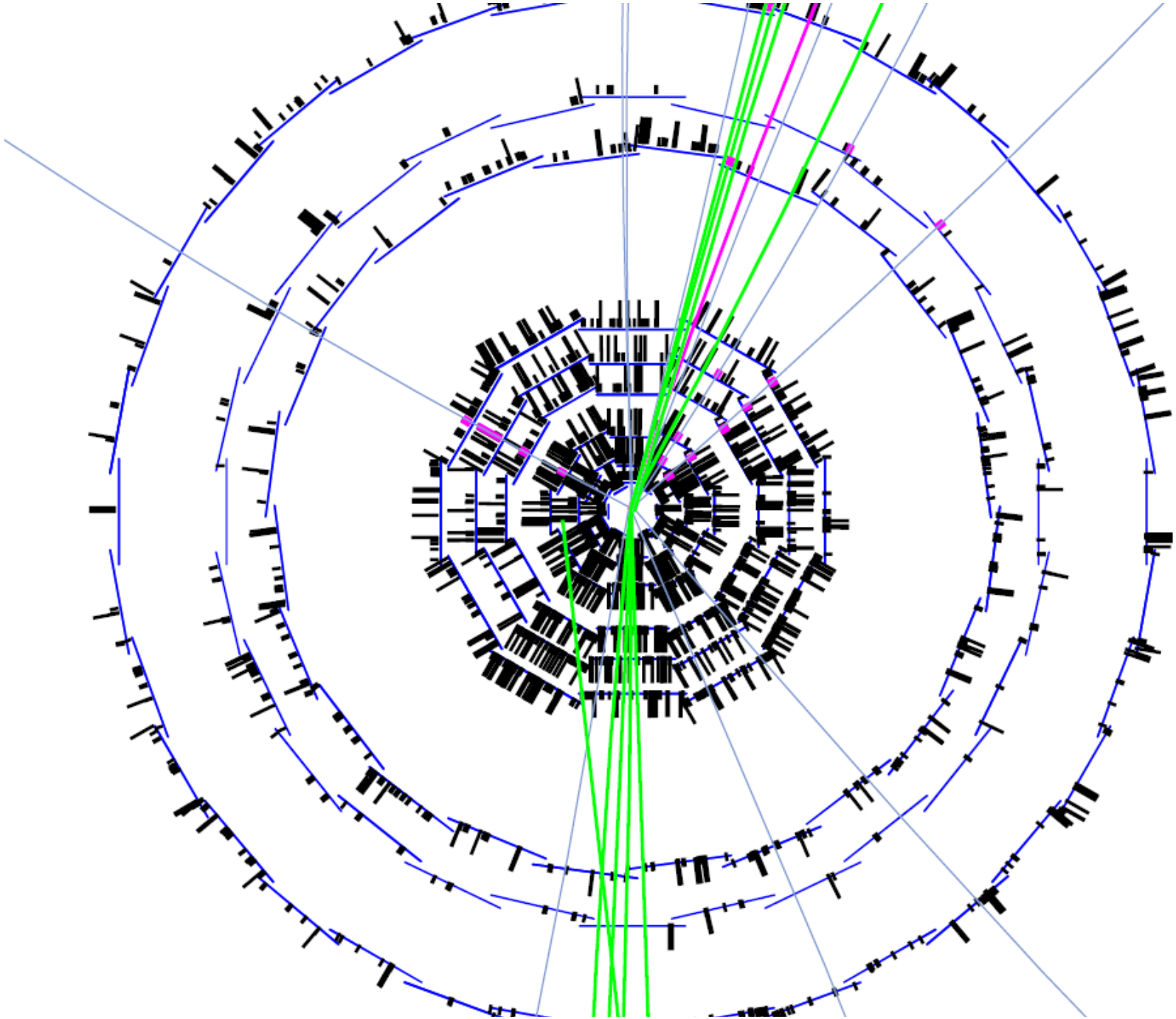


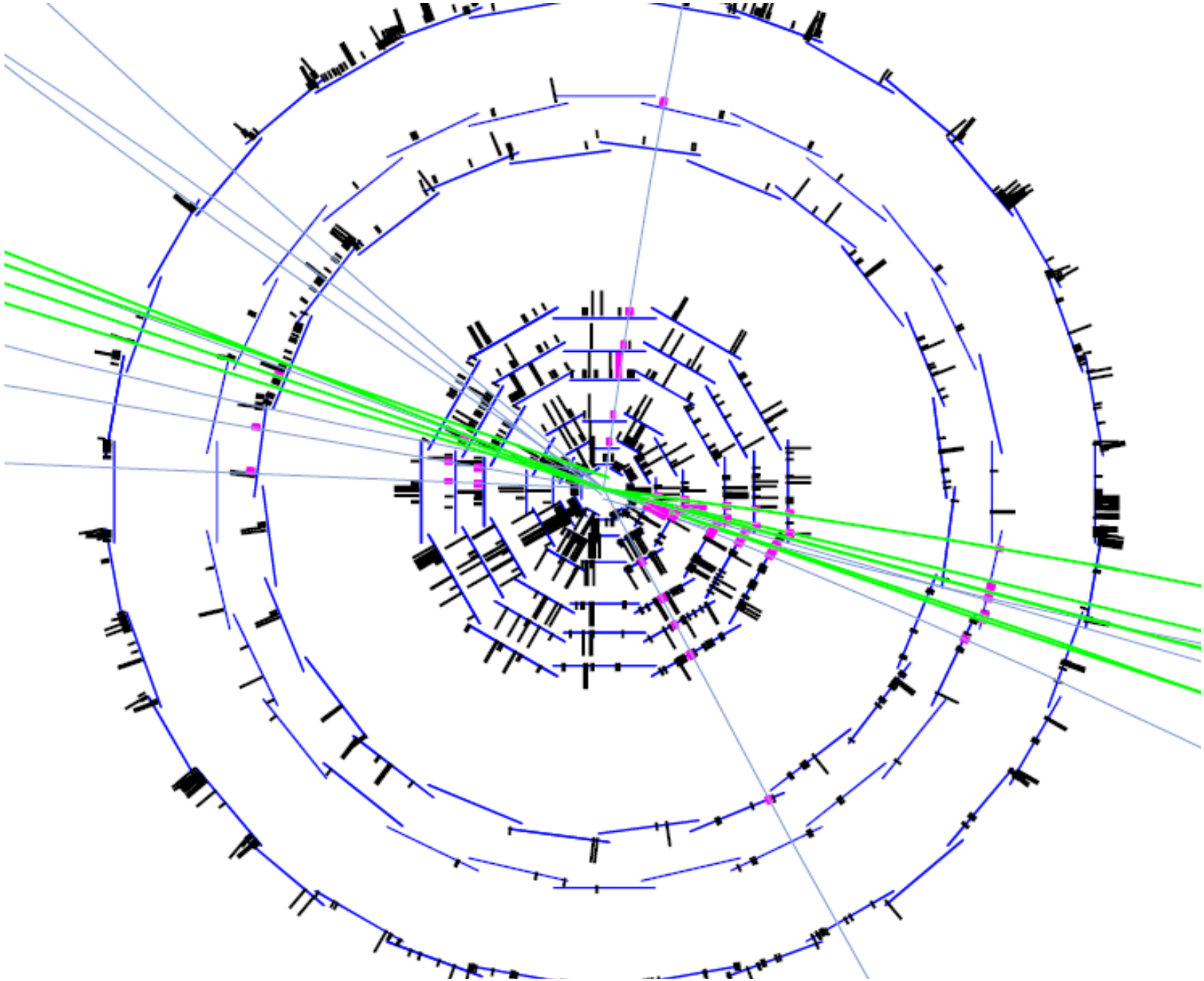




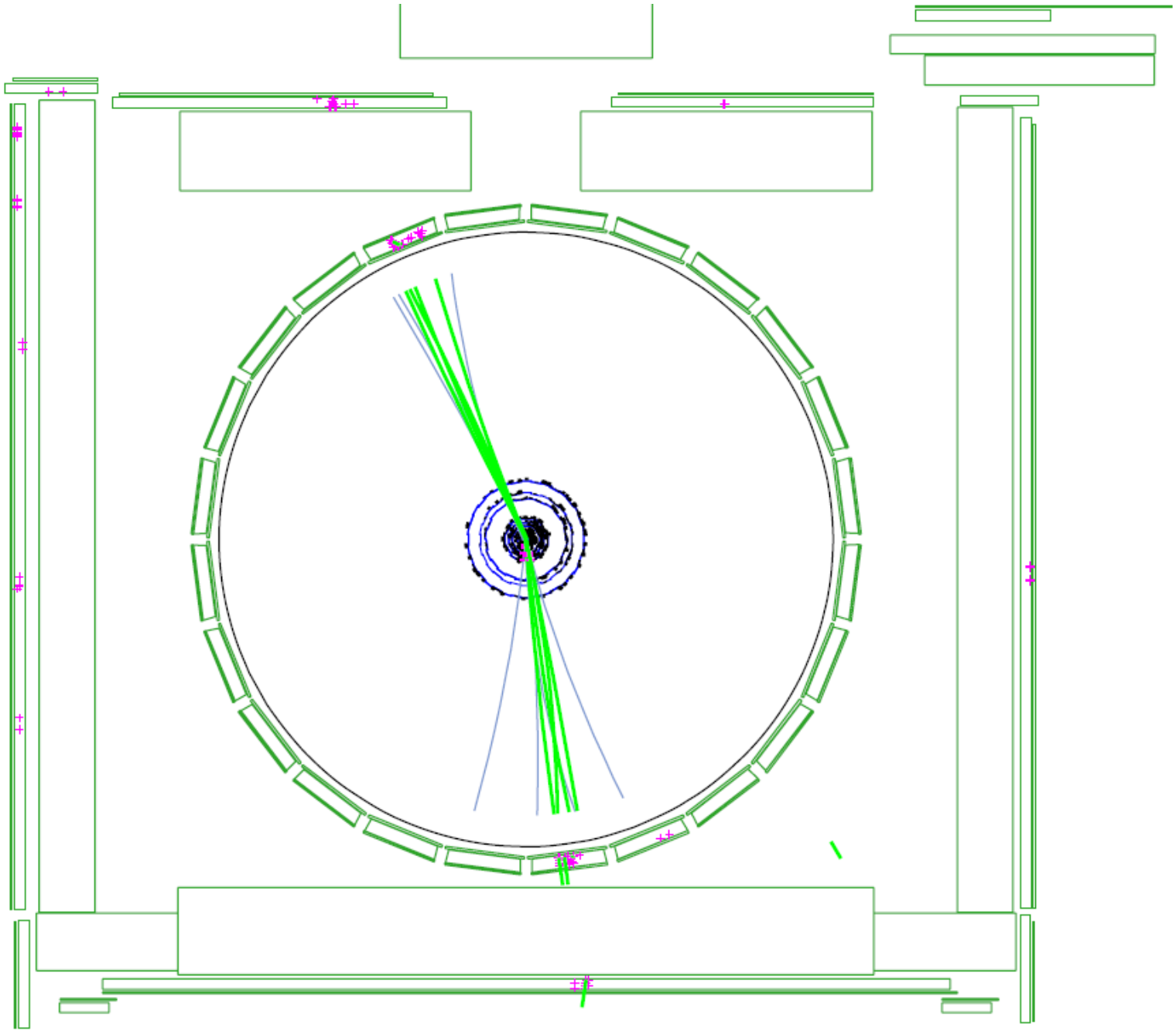


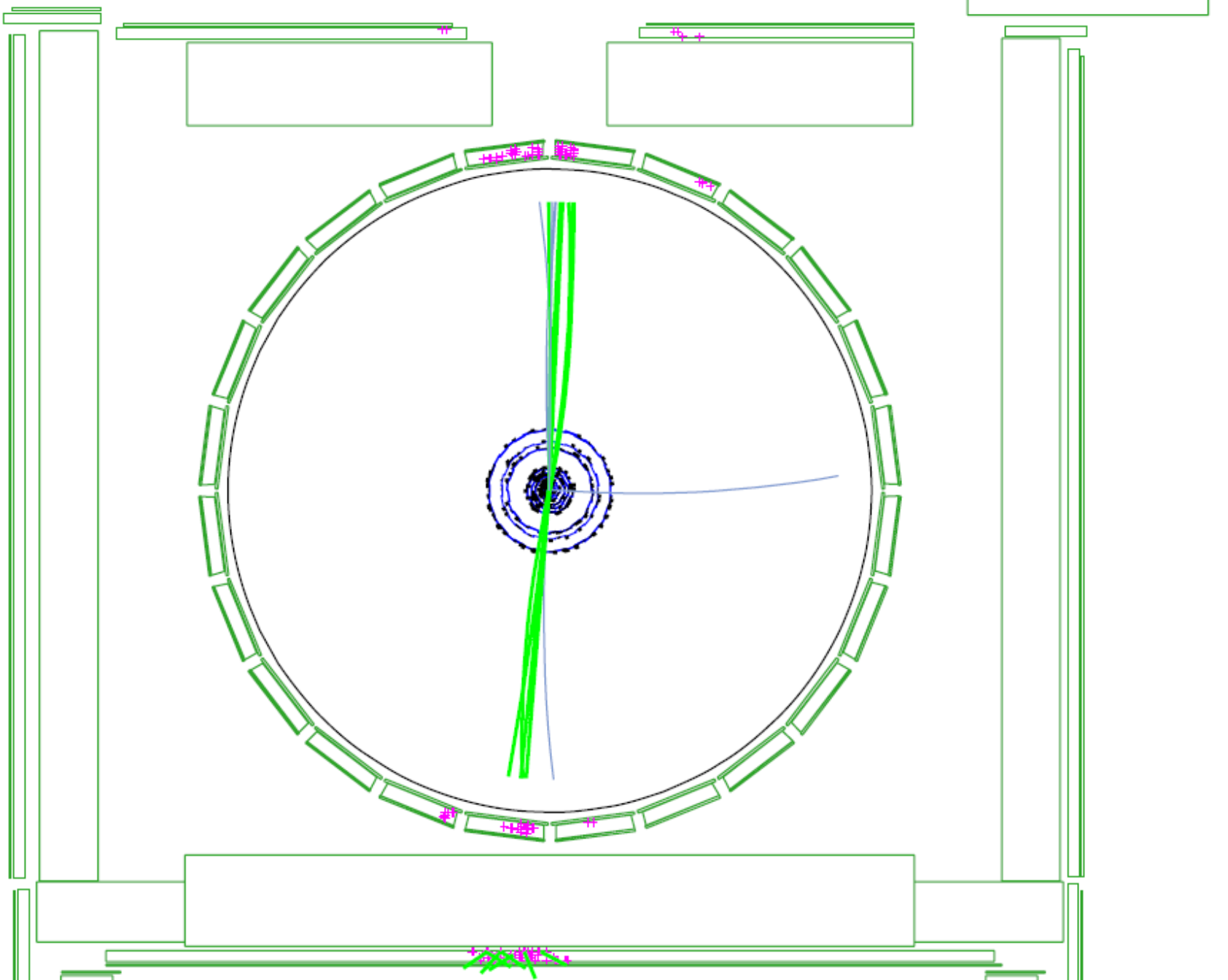


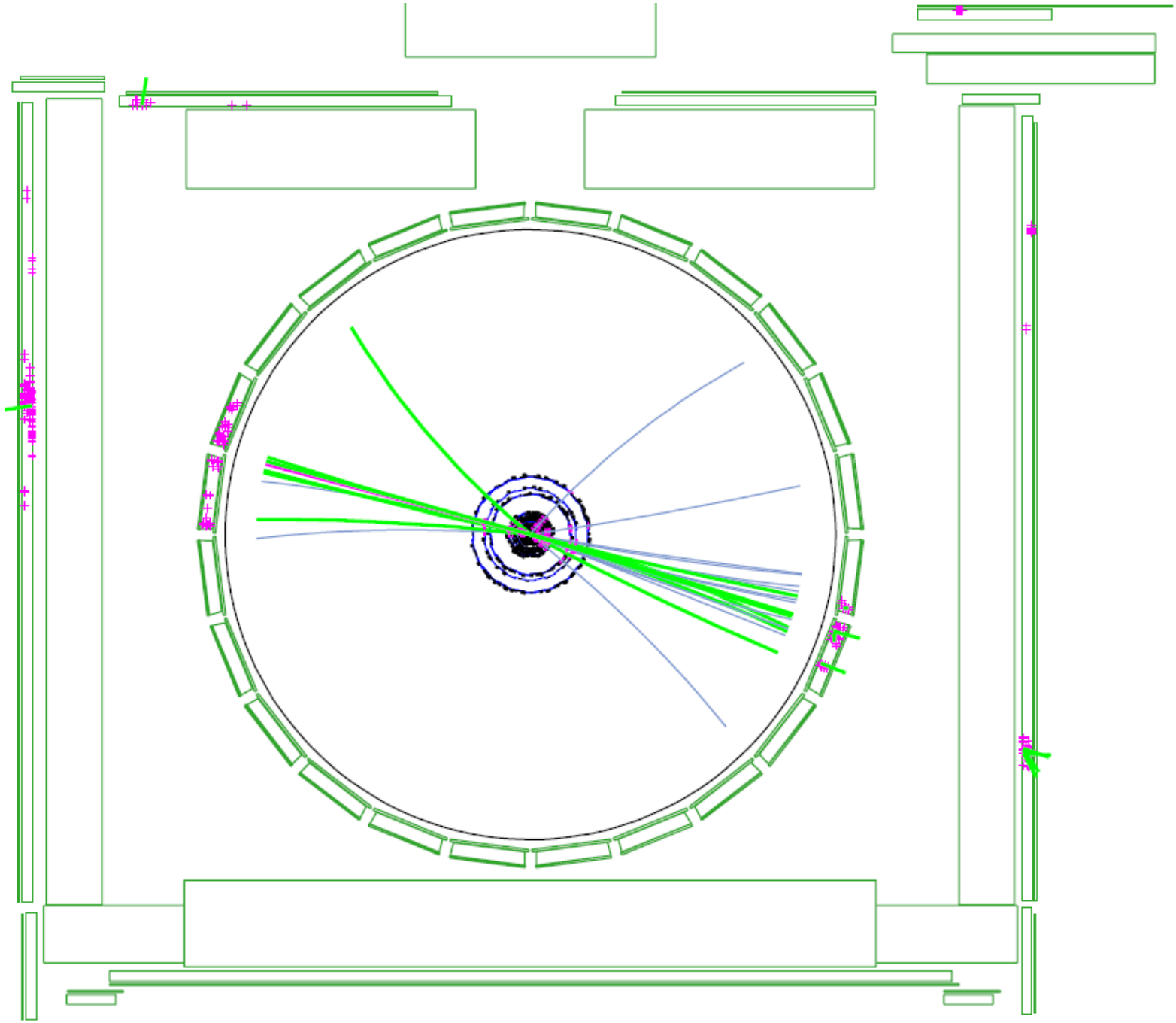


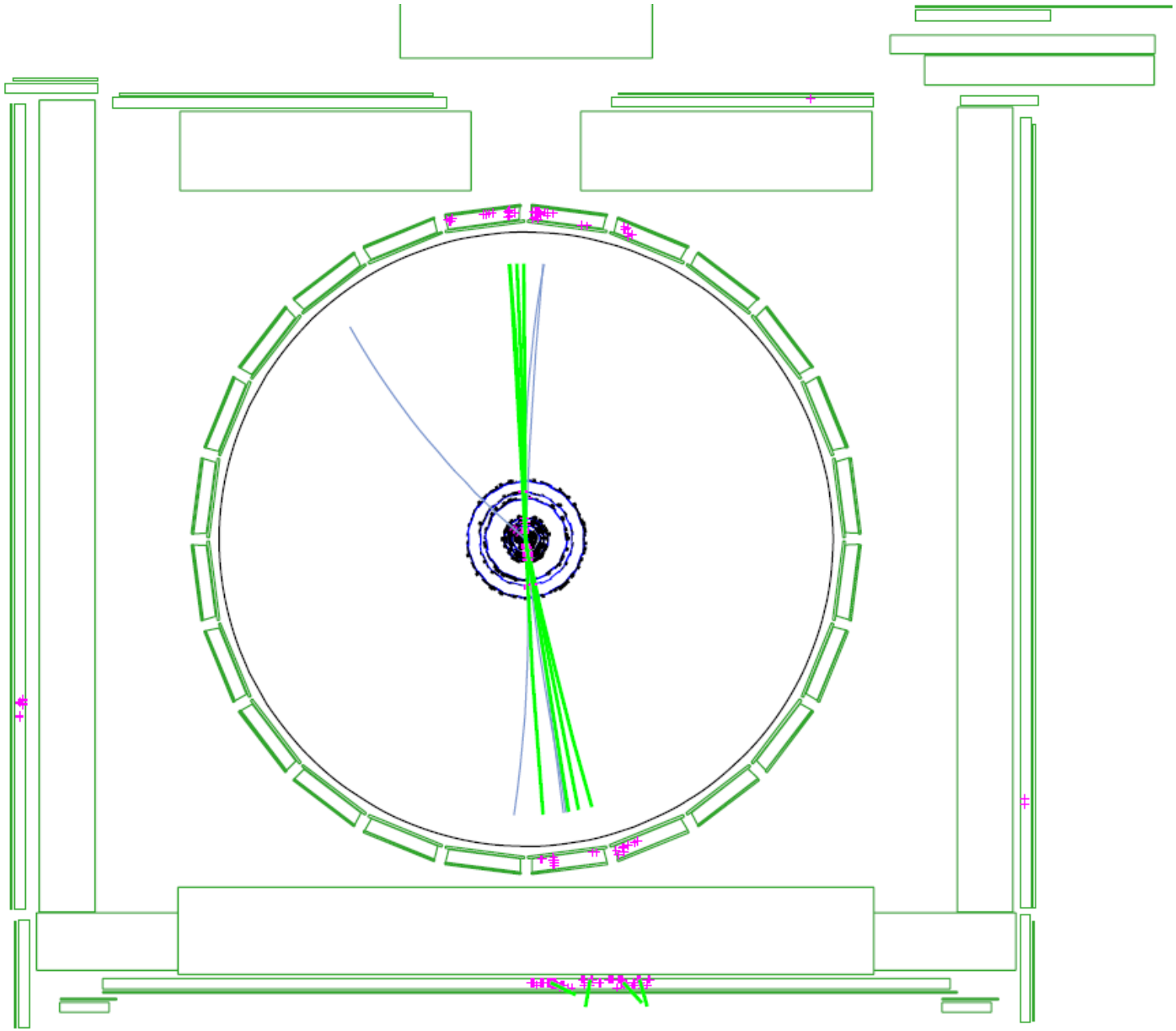


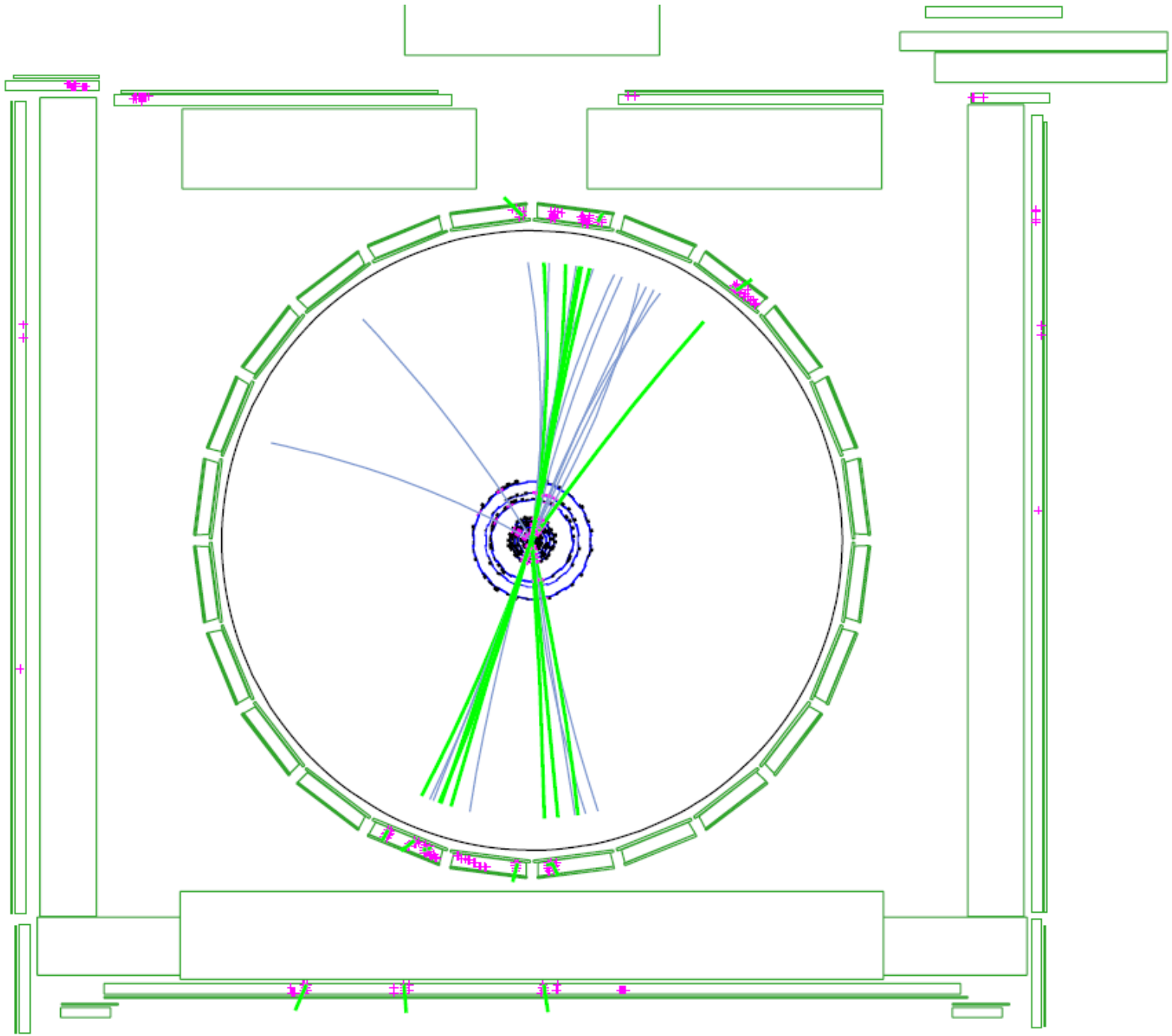
Muons spare

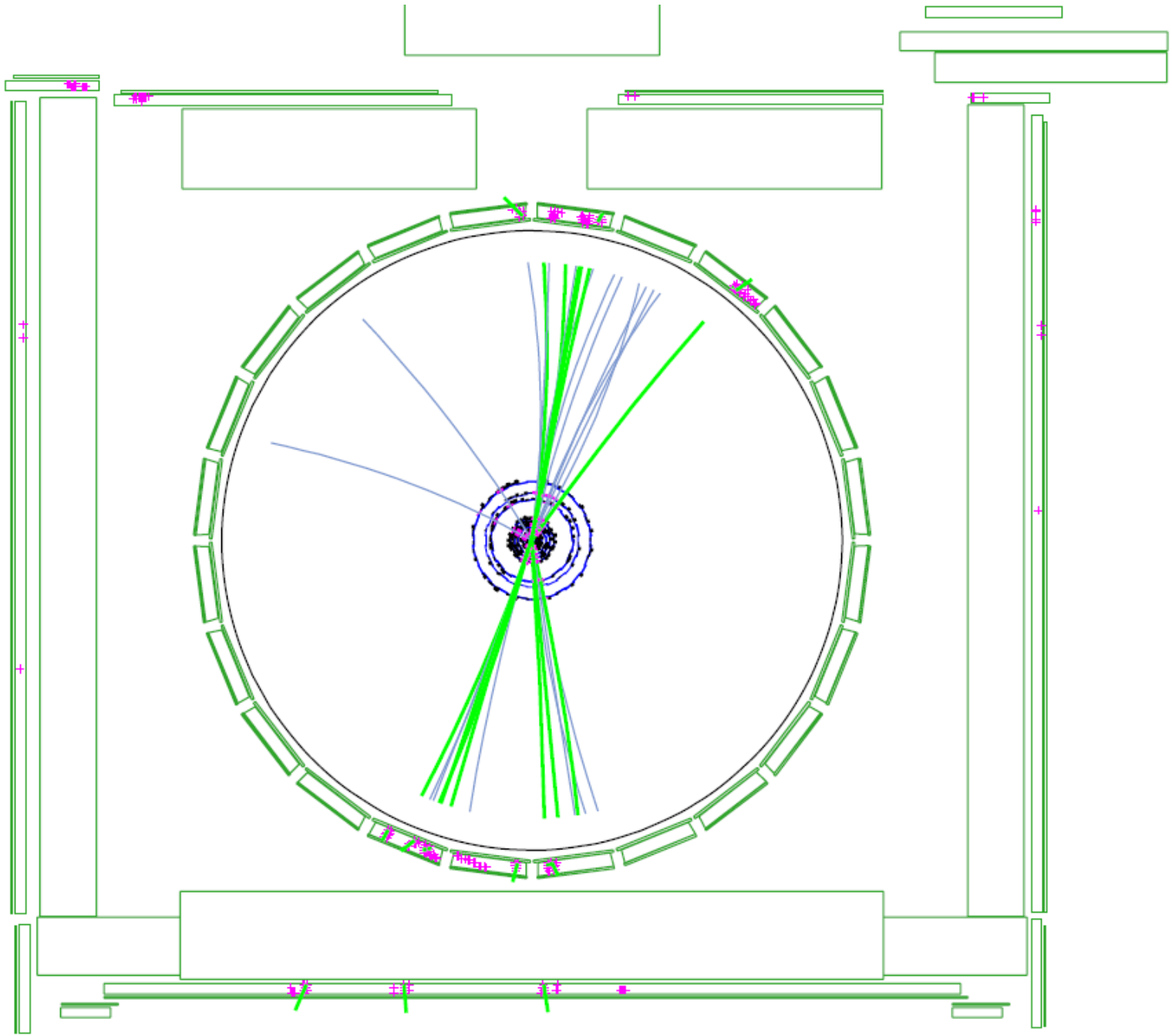


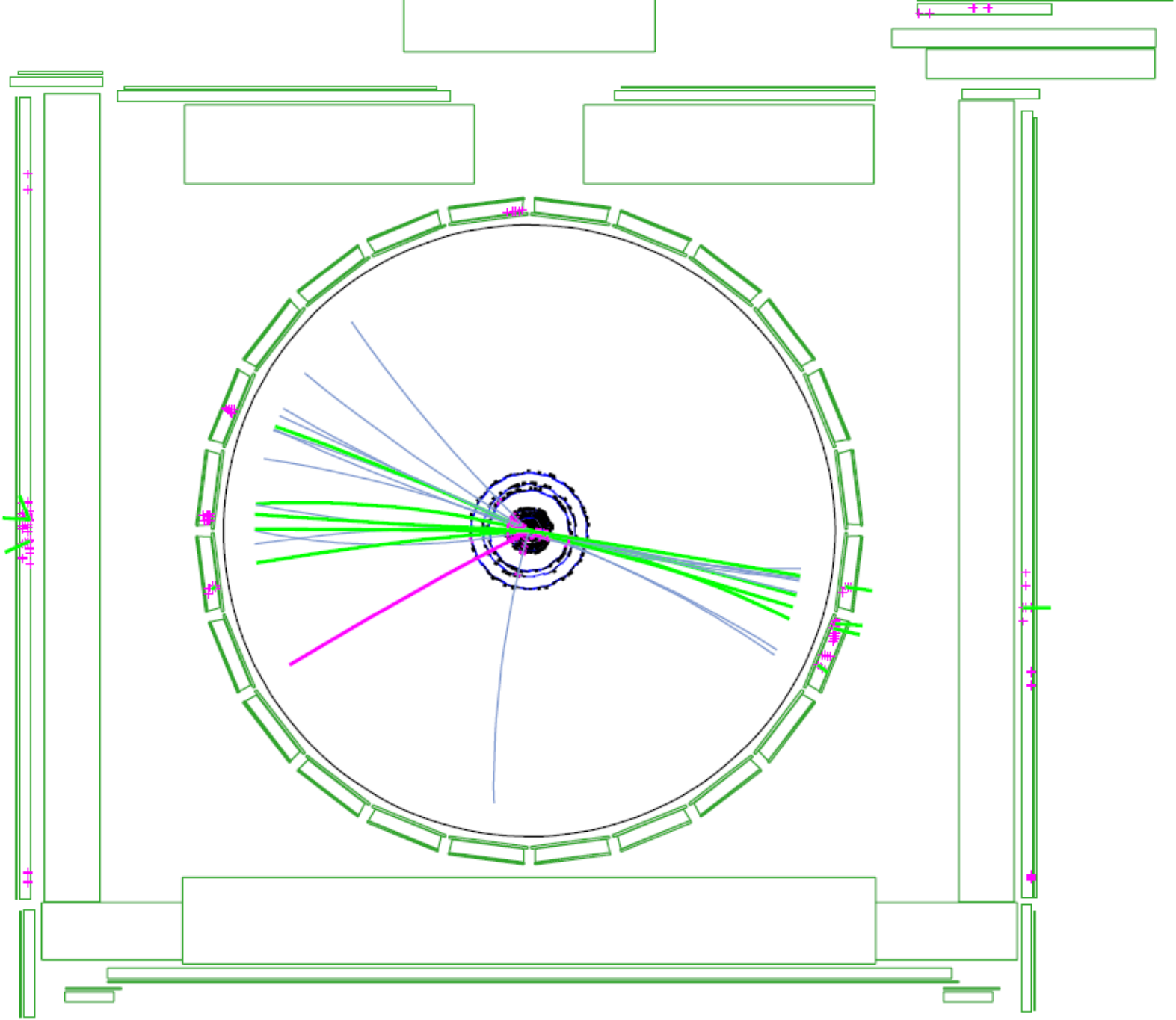


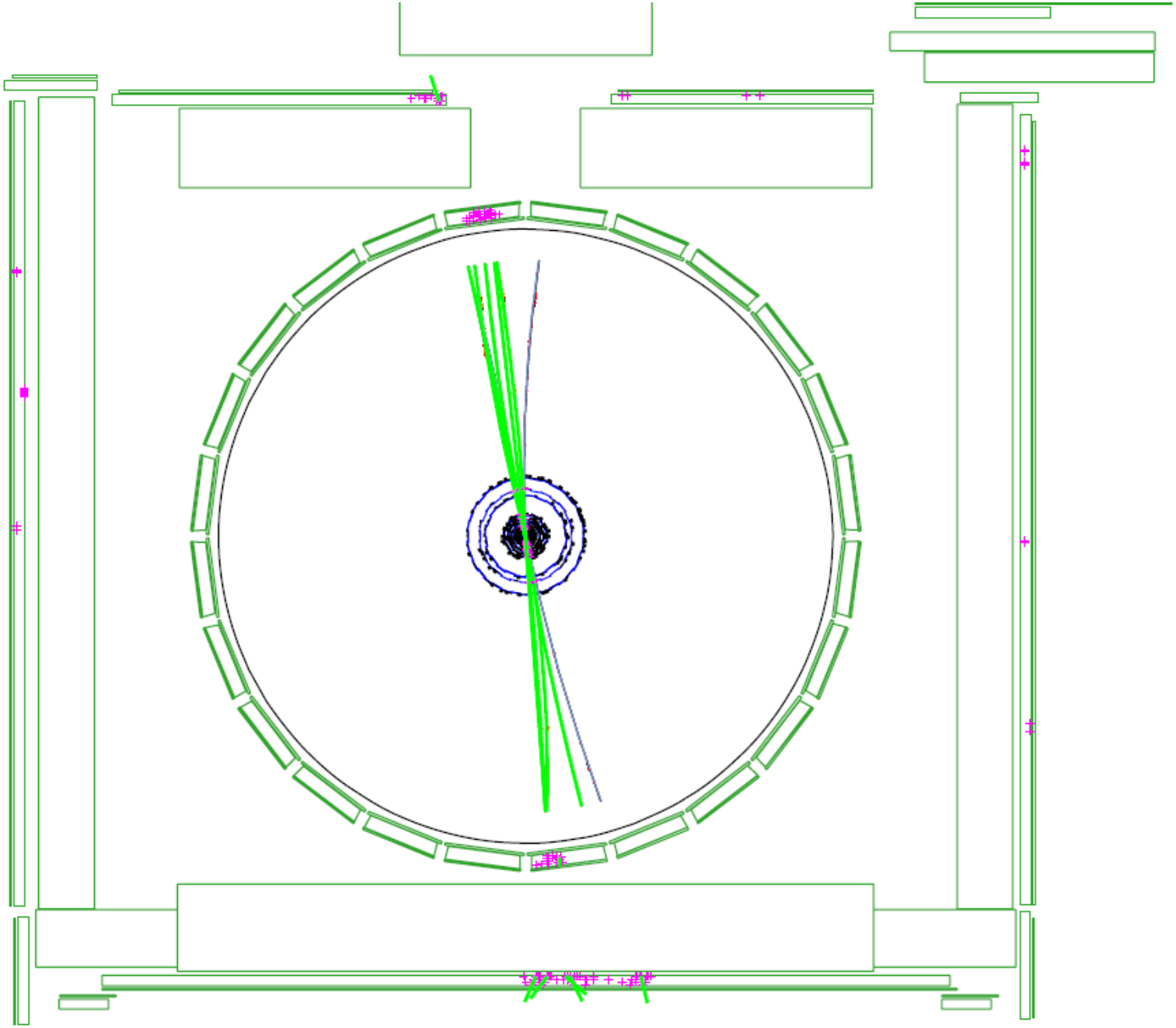


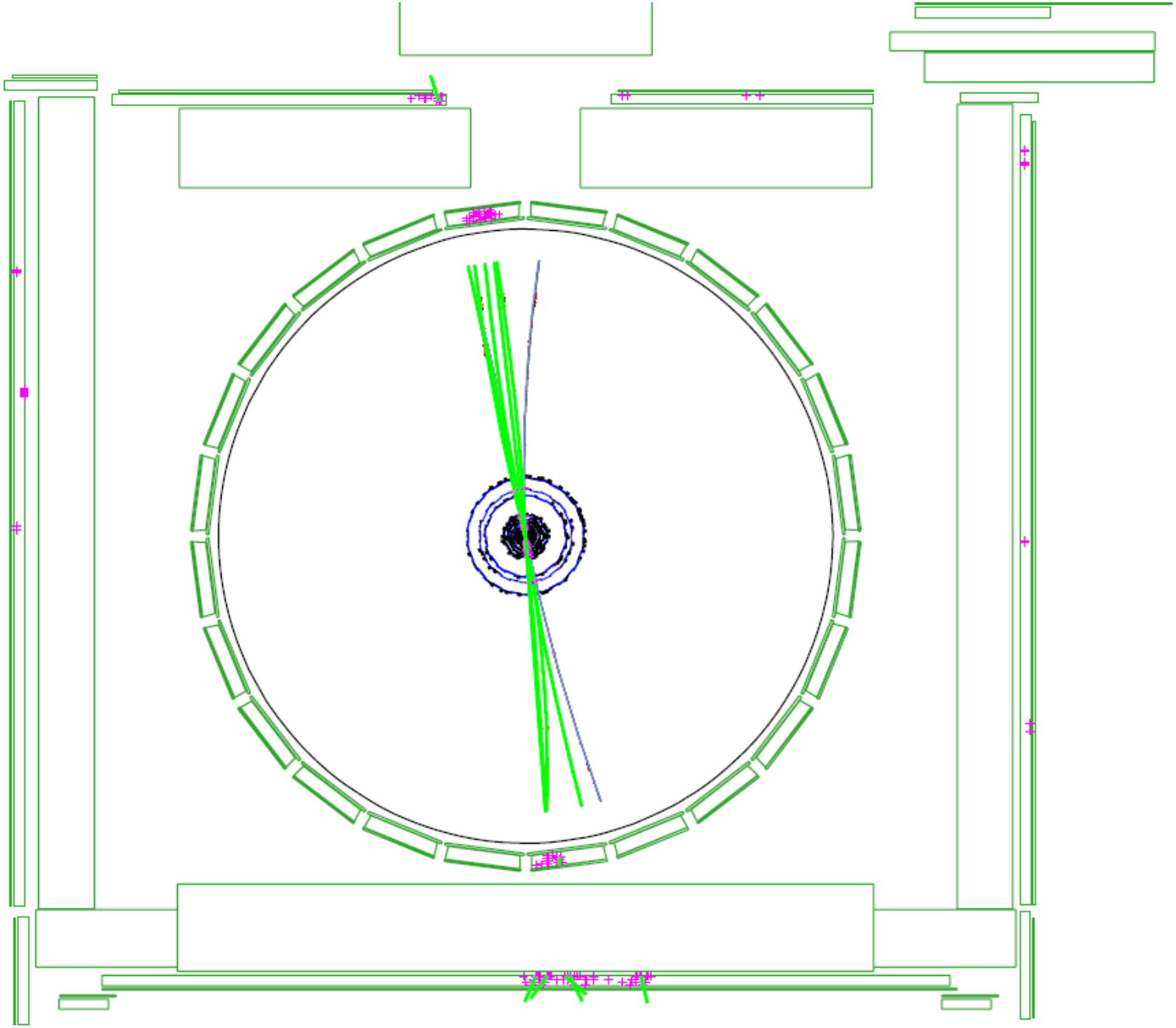


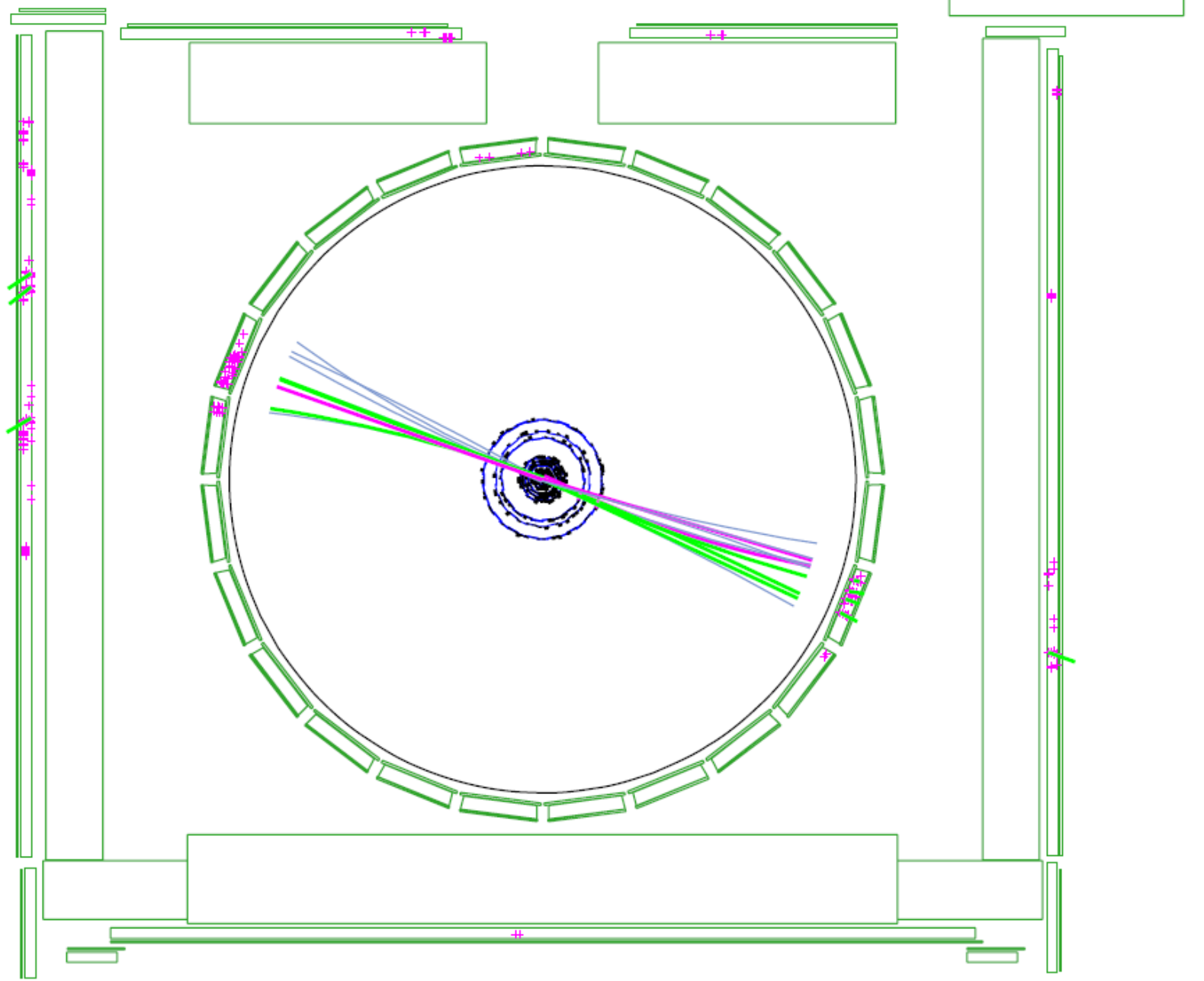


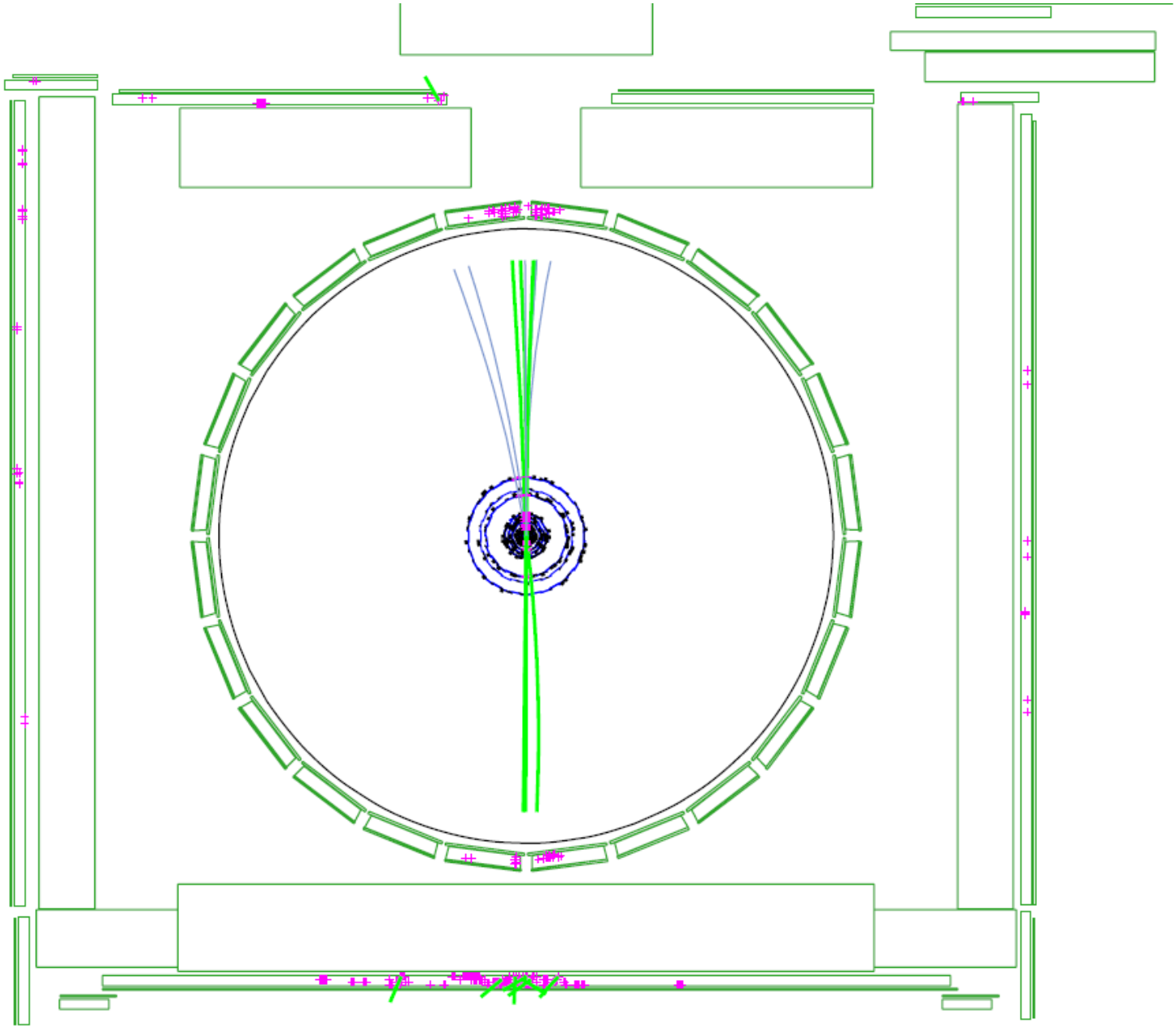


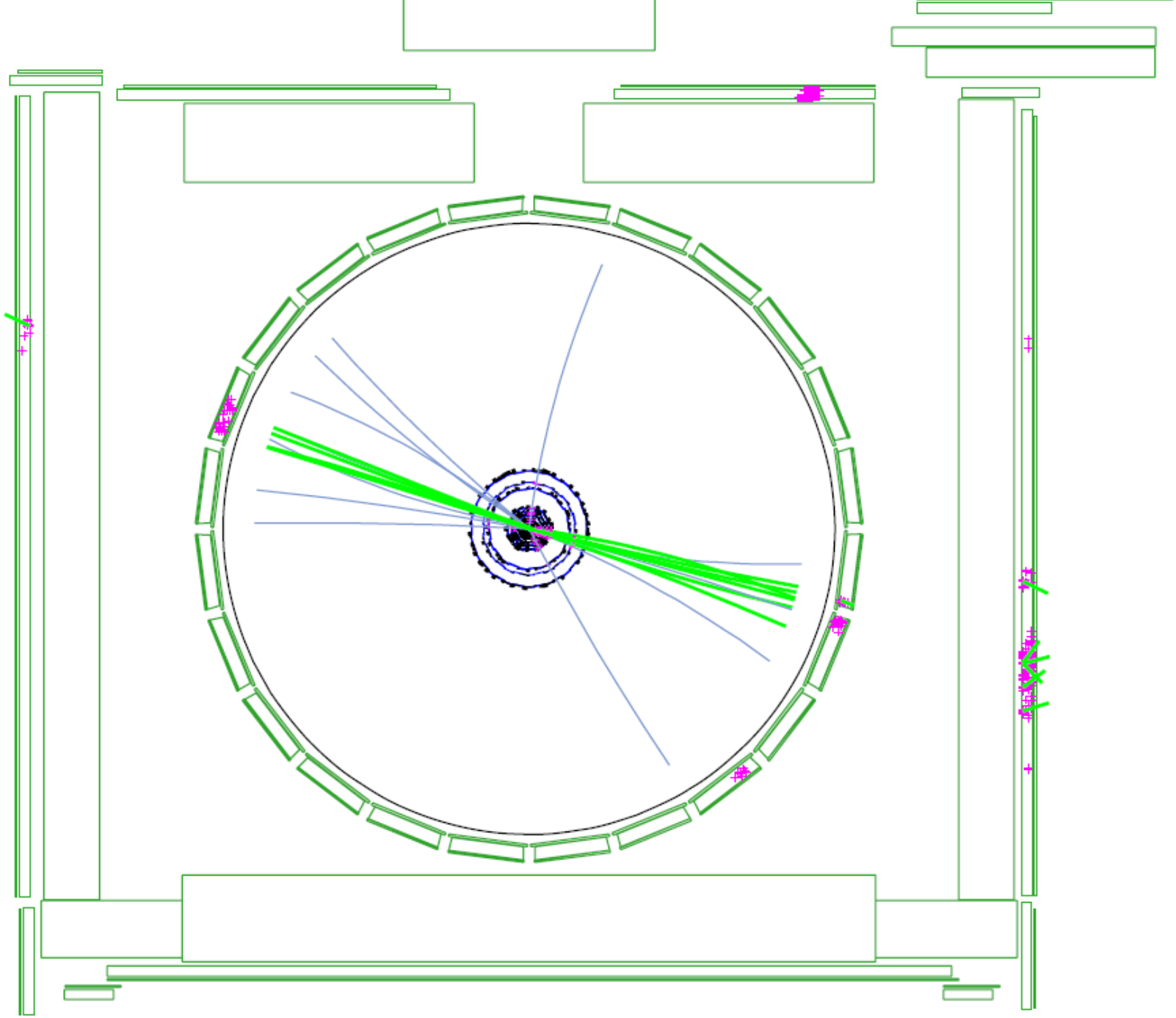


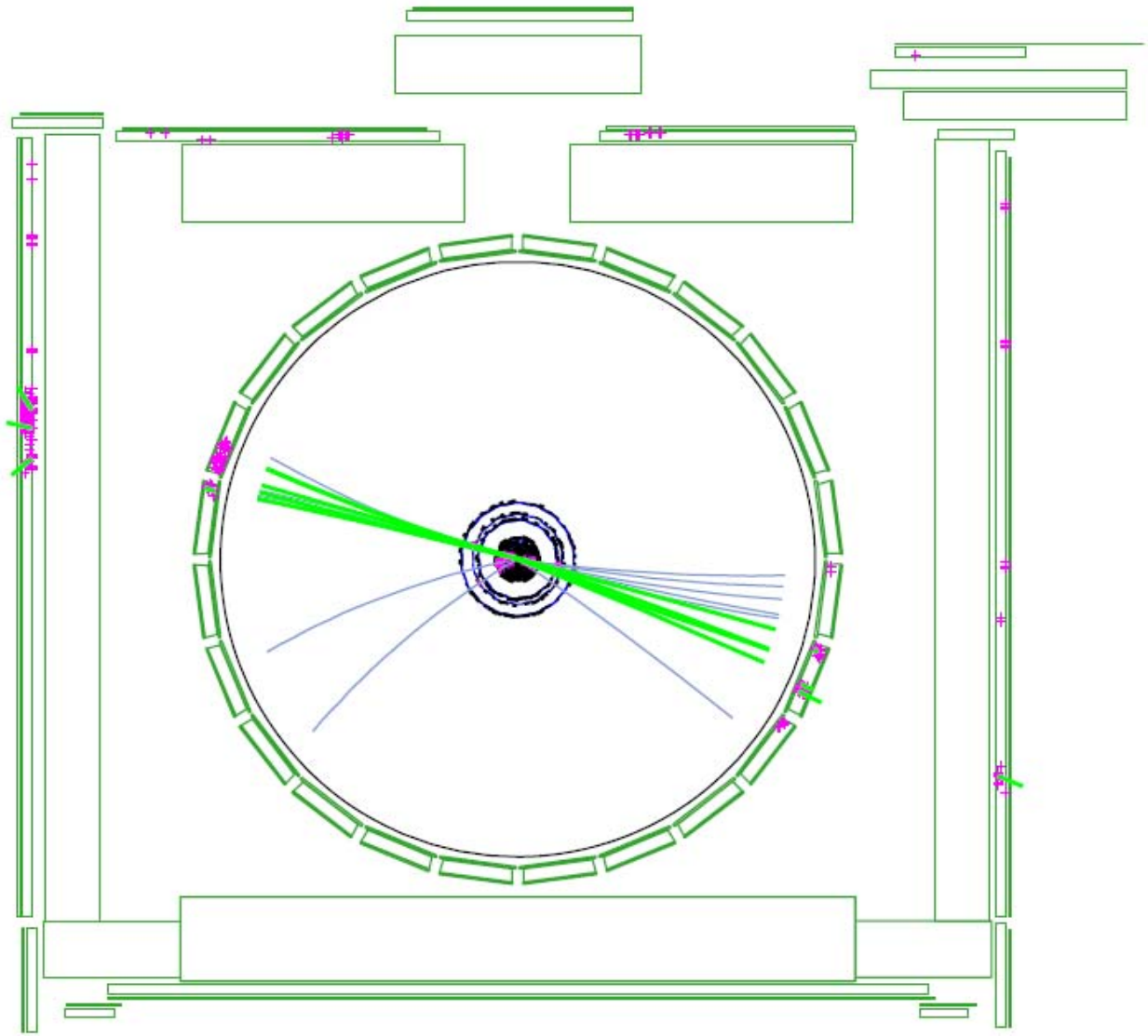


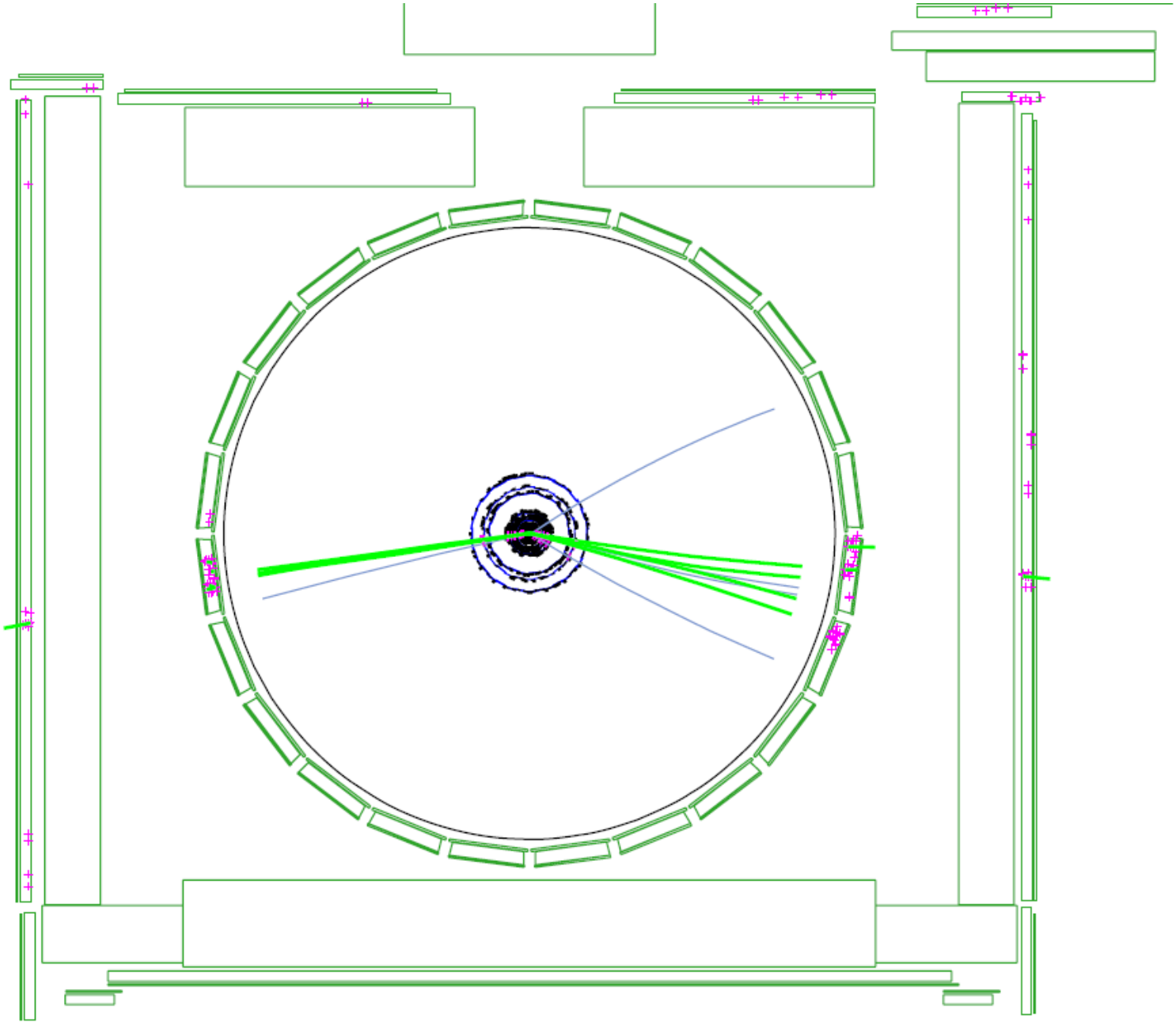


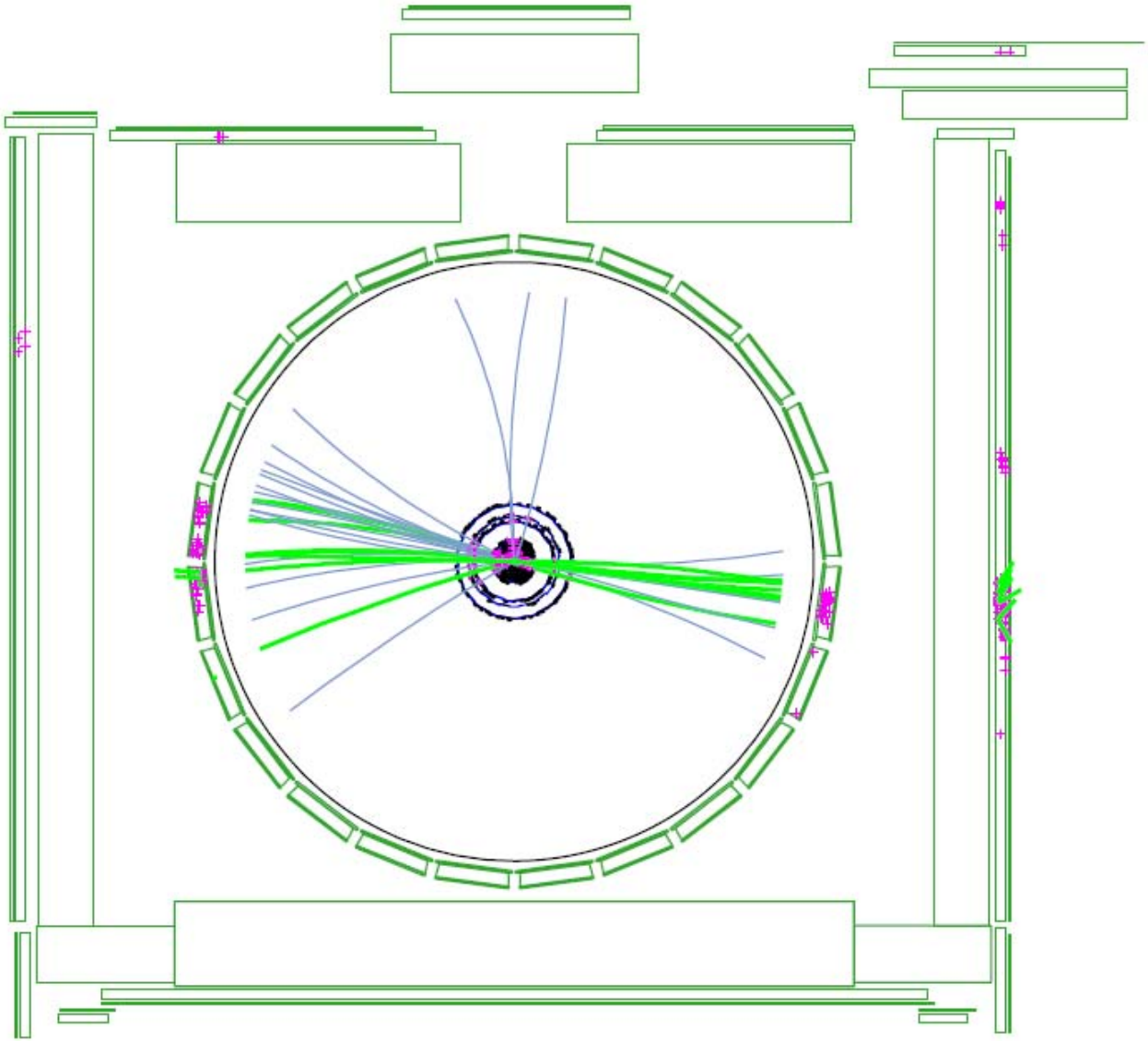


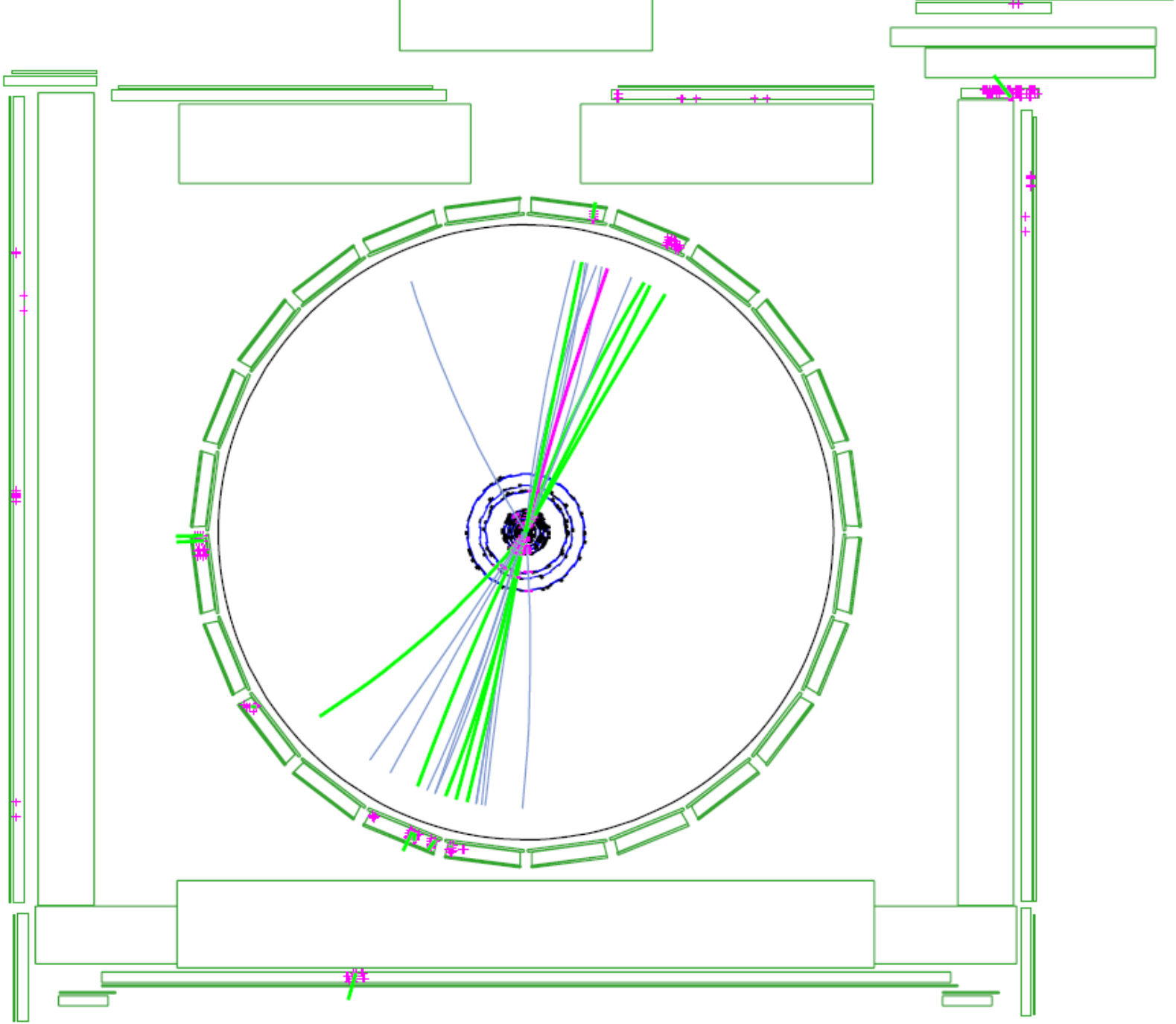


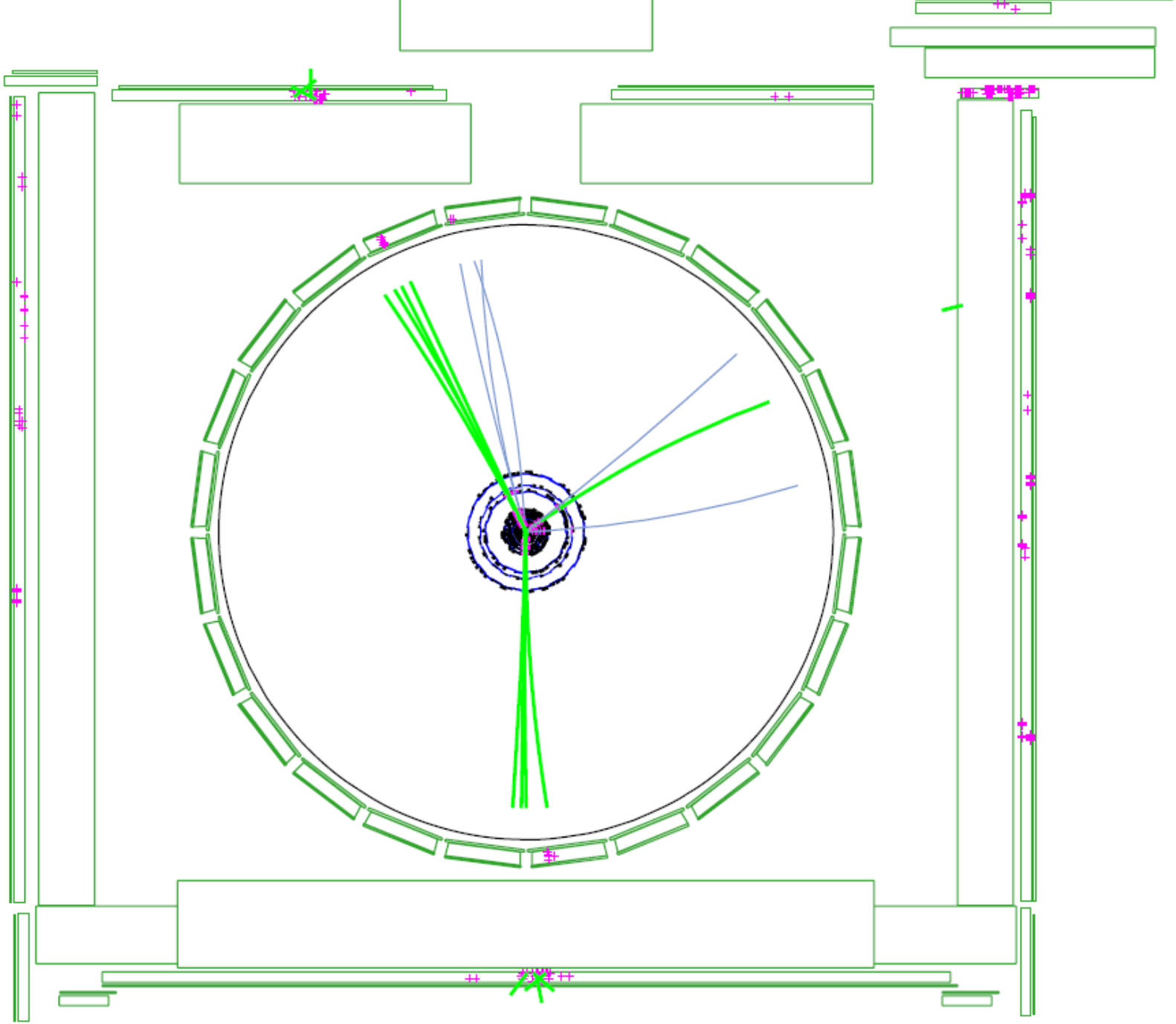


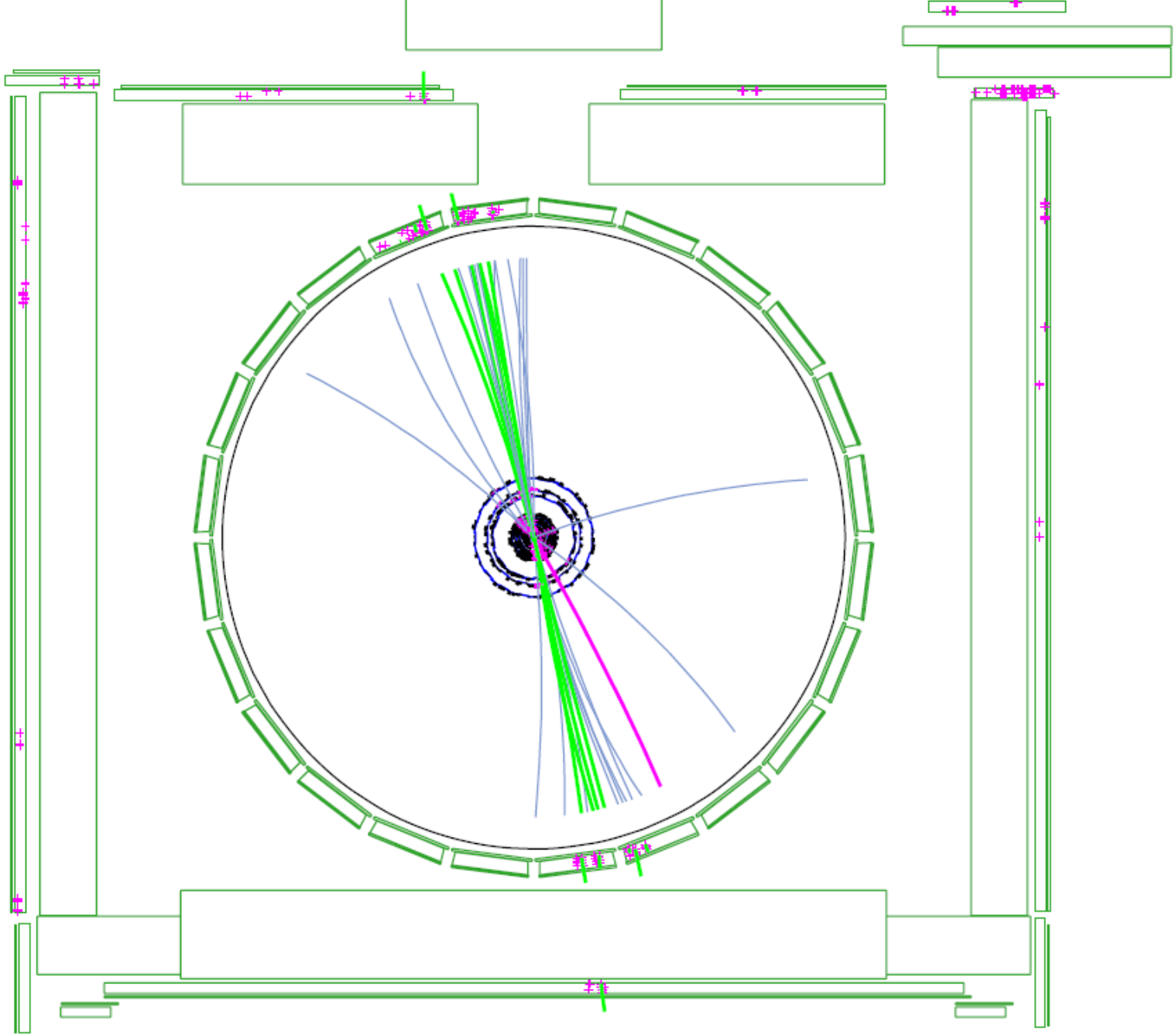


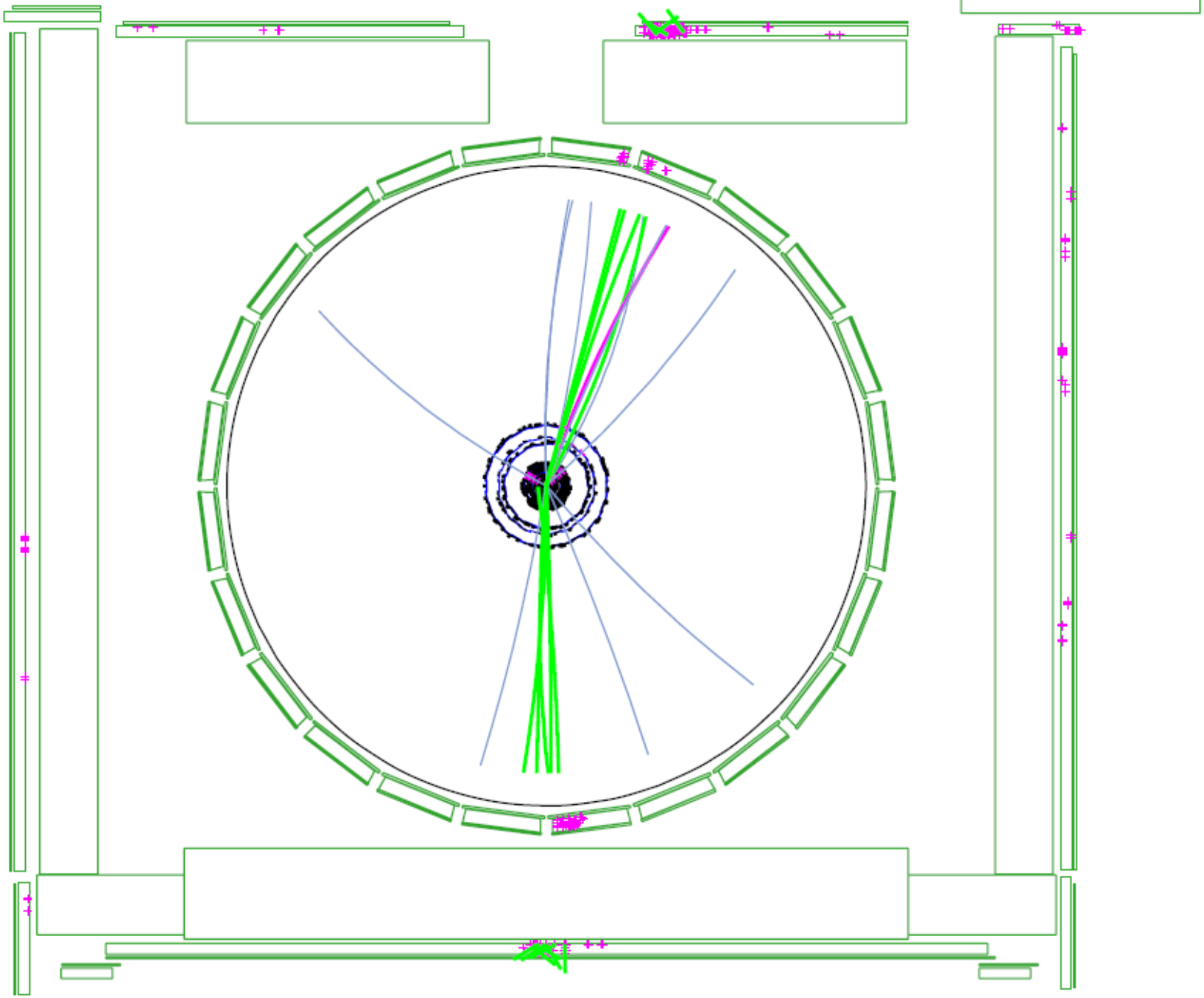


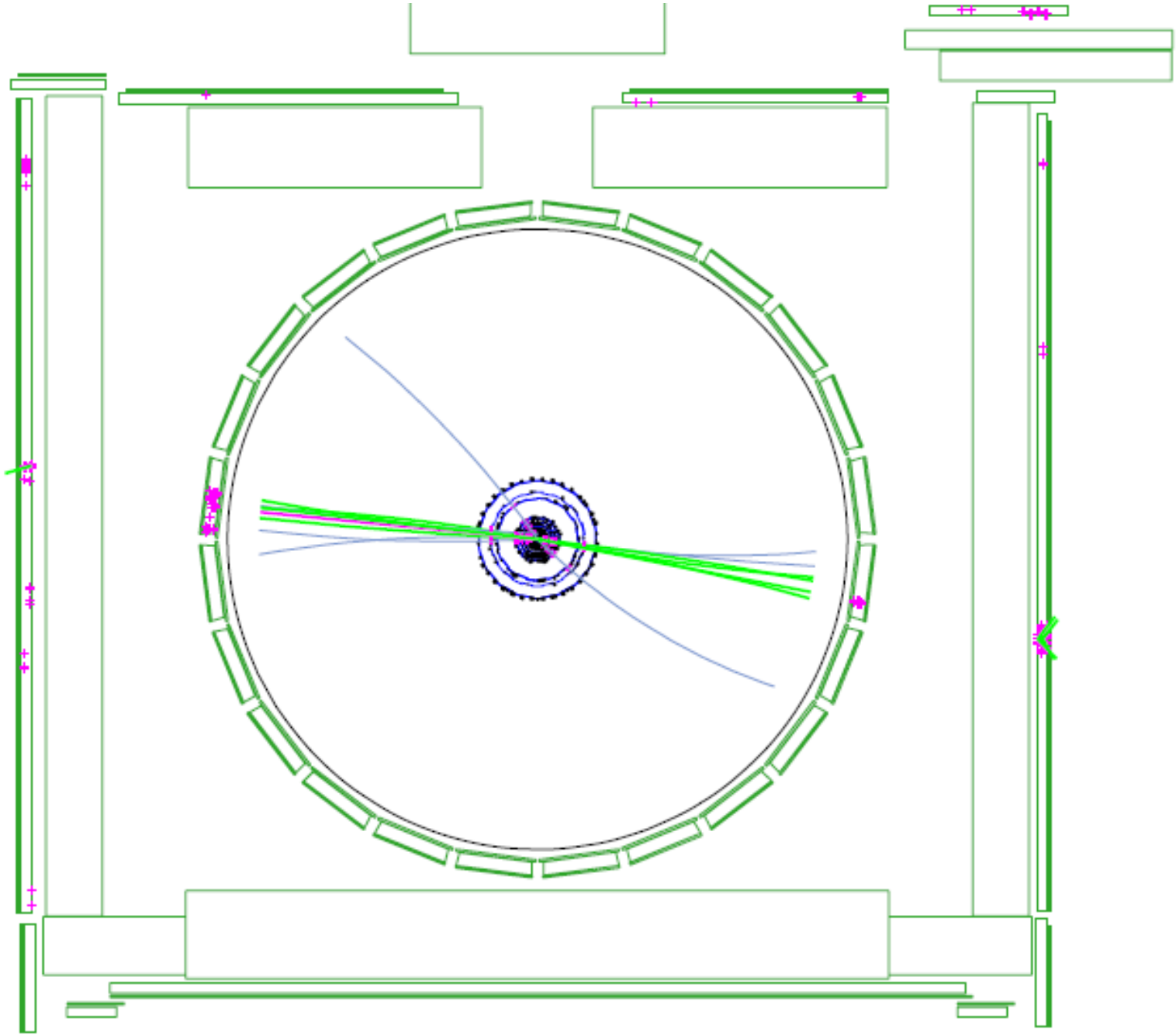


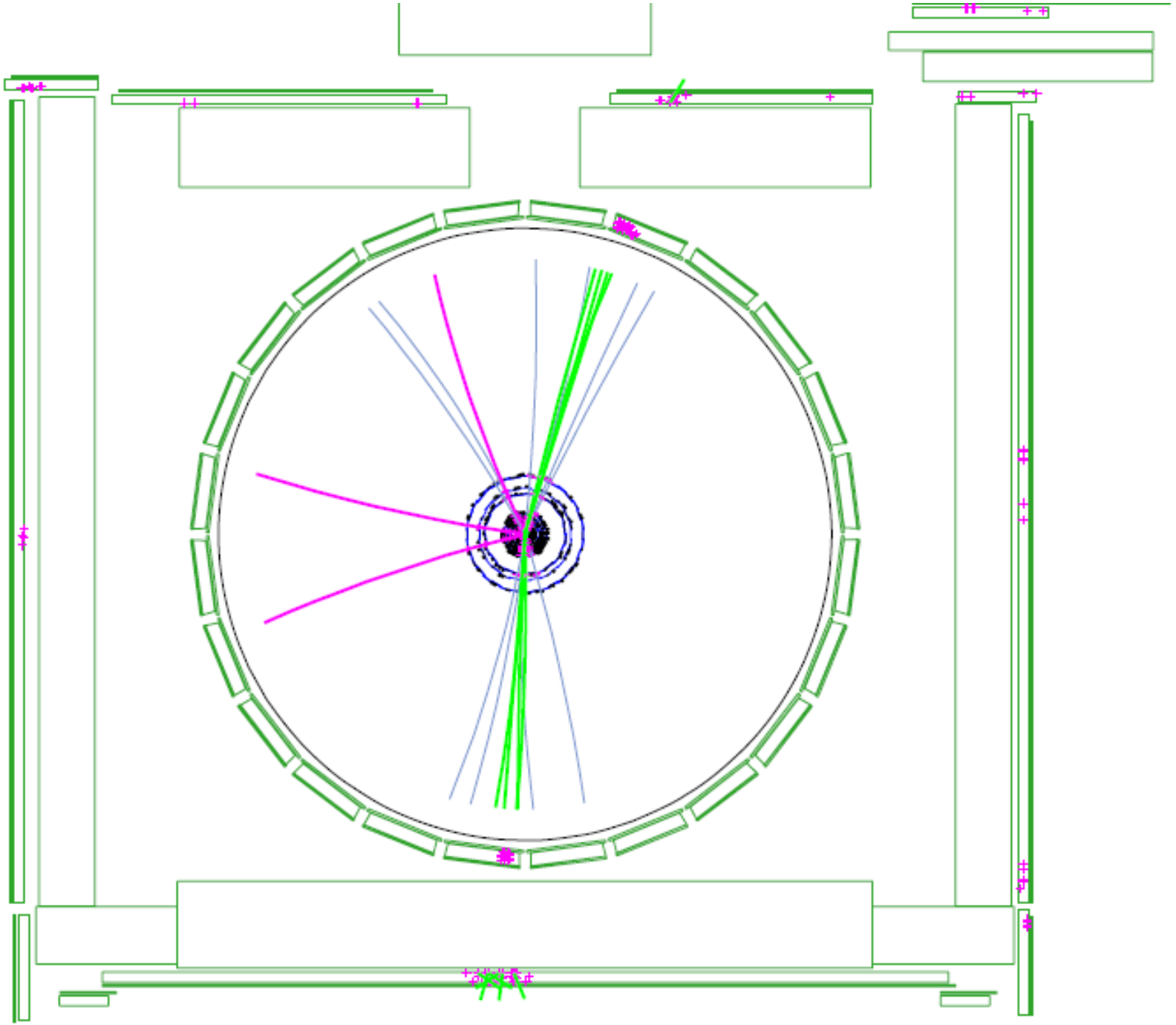


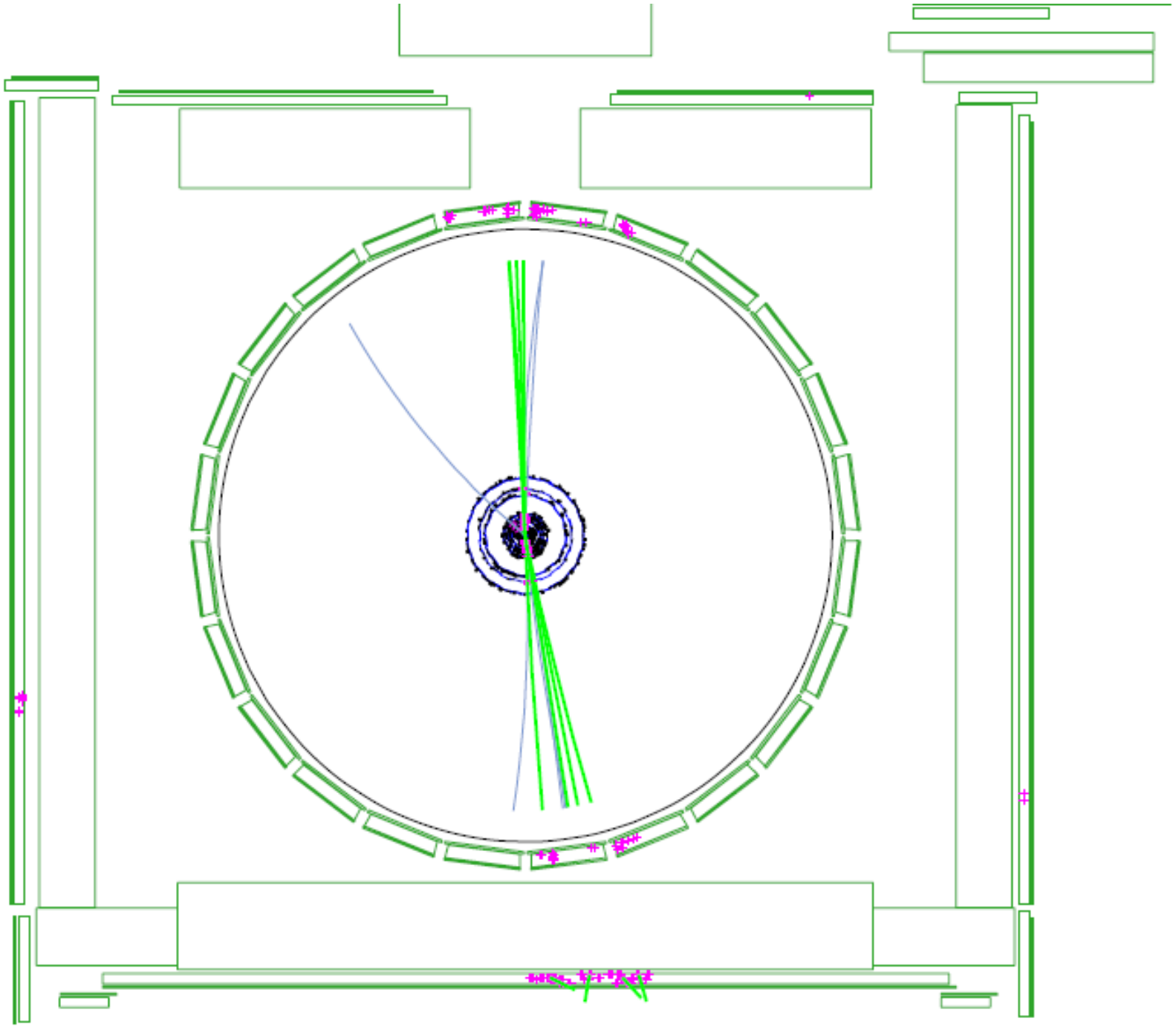


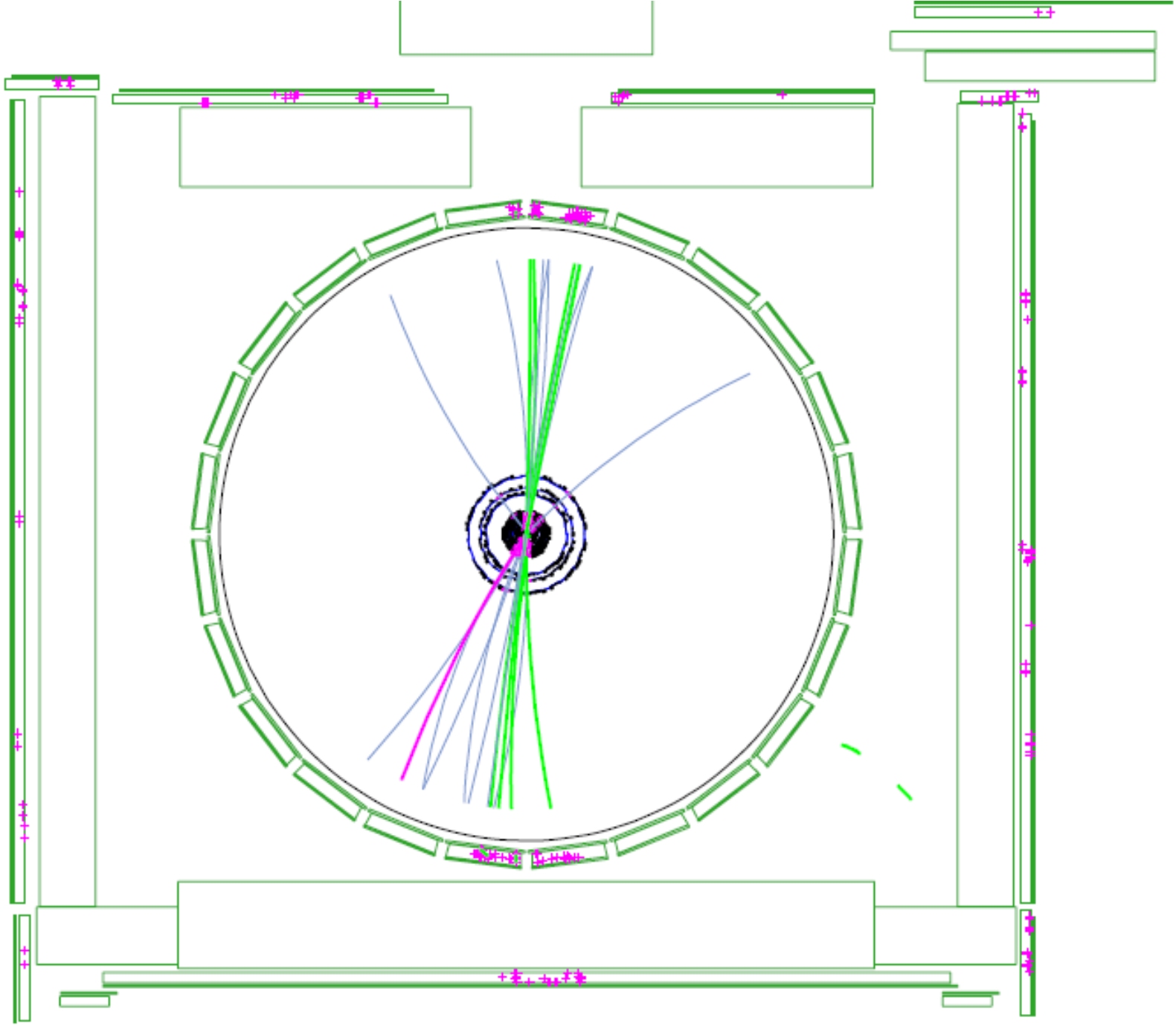


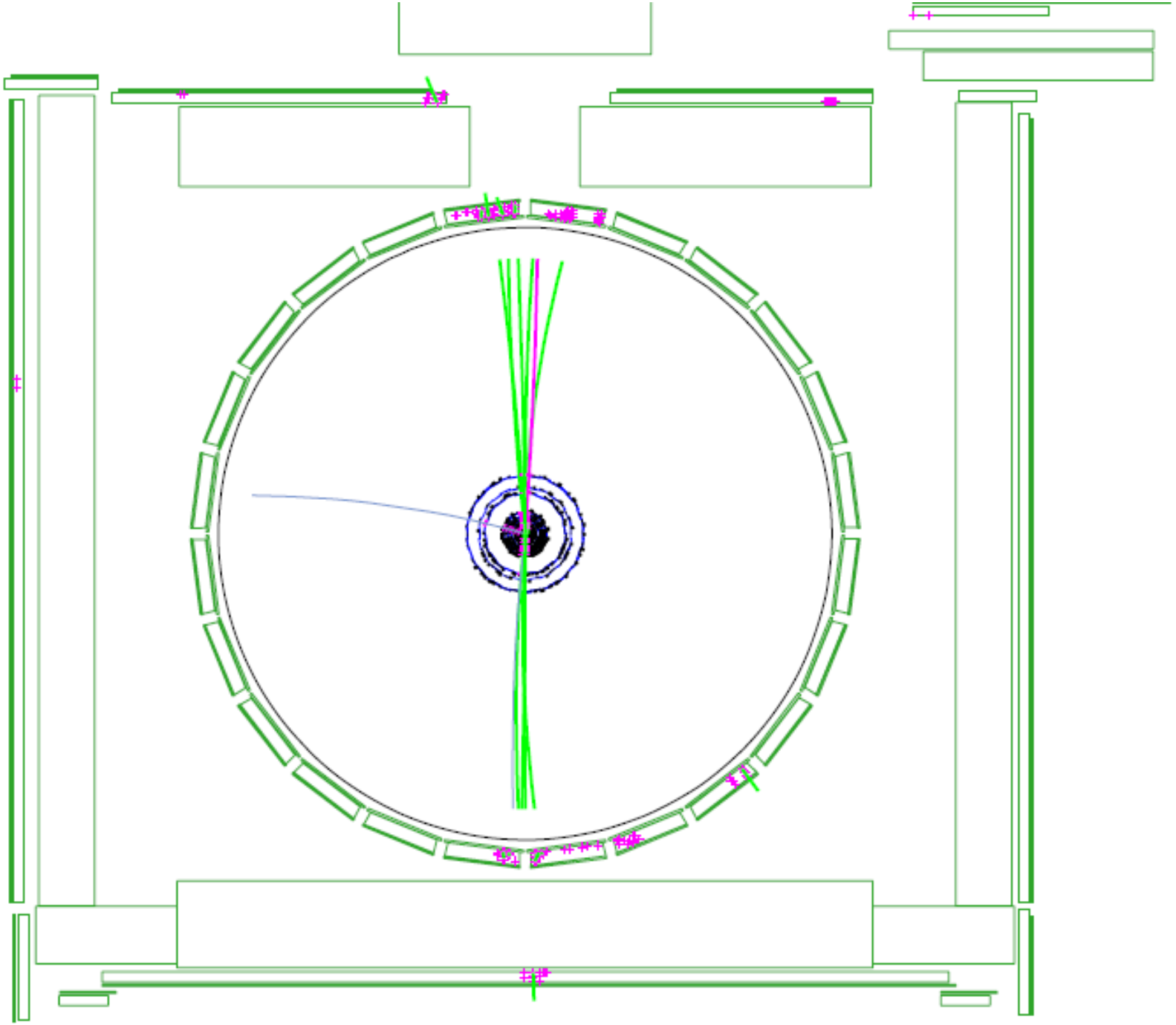


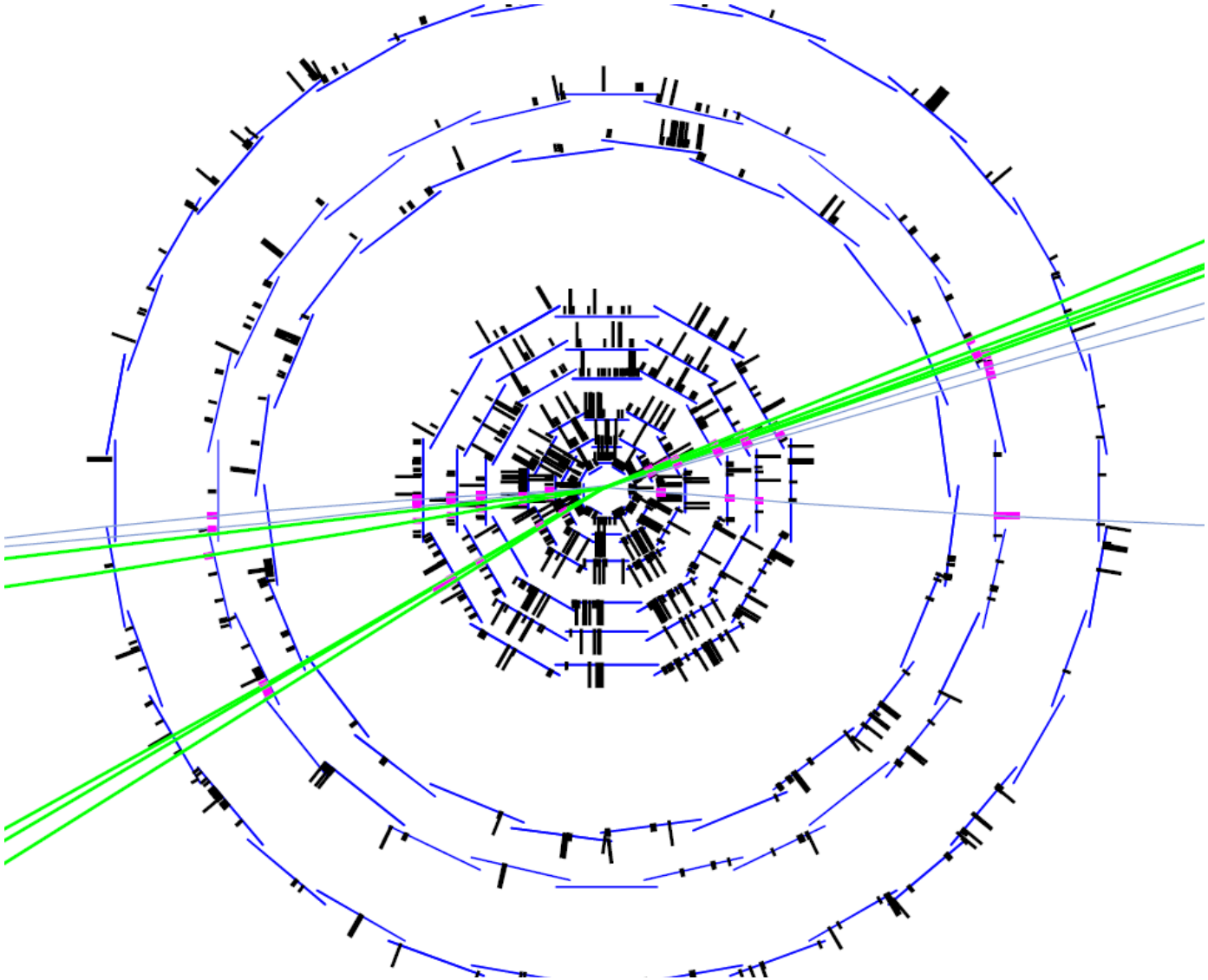


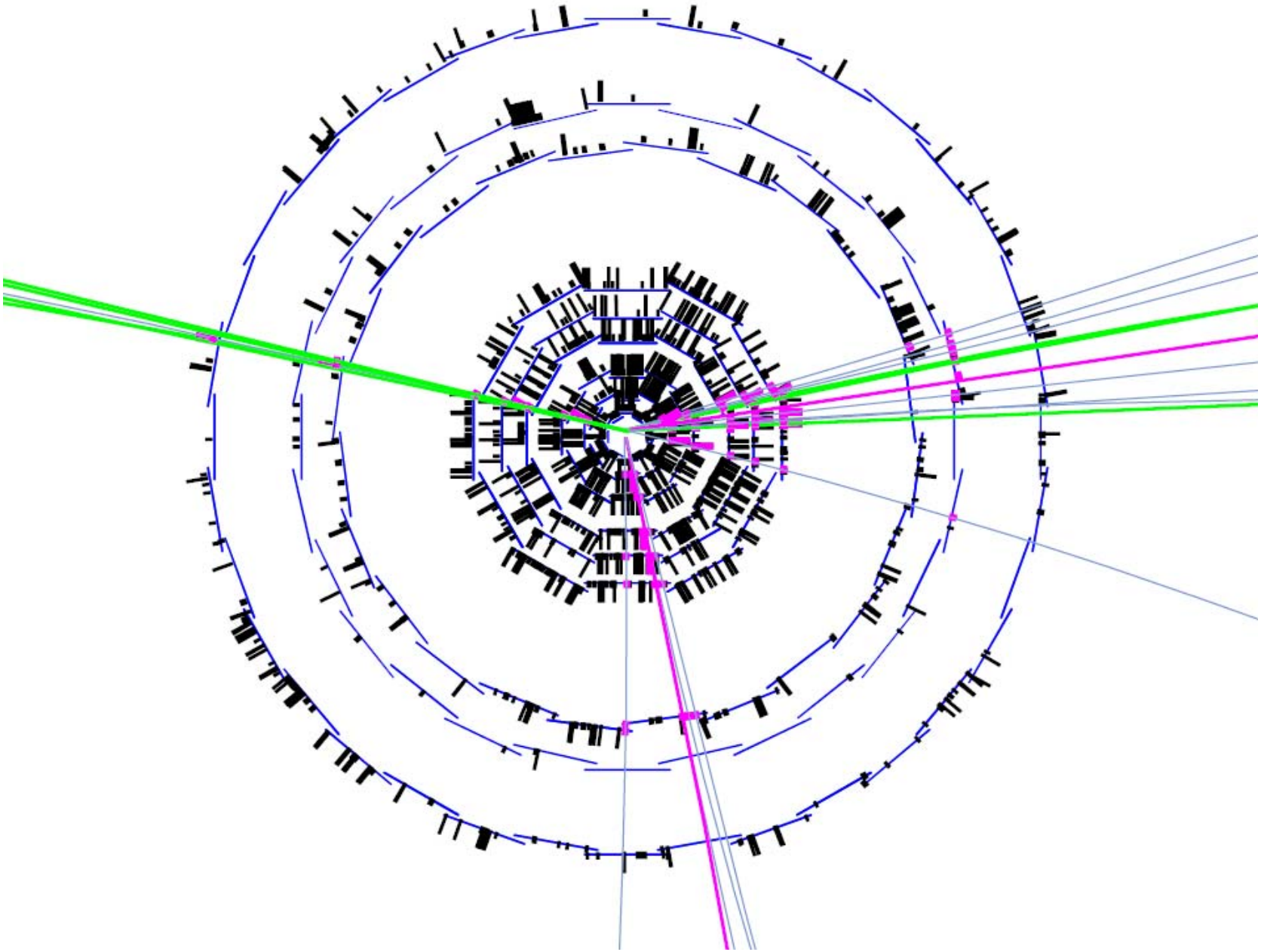


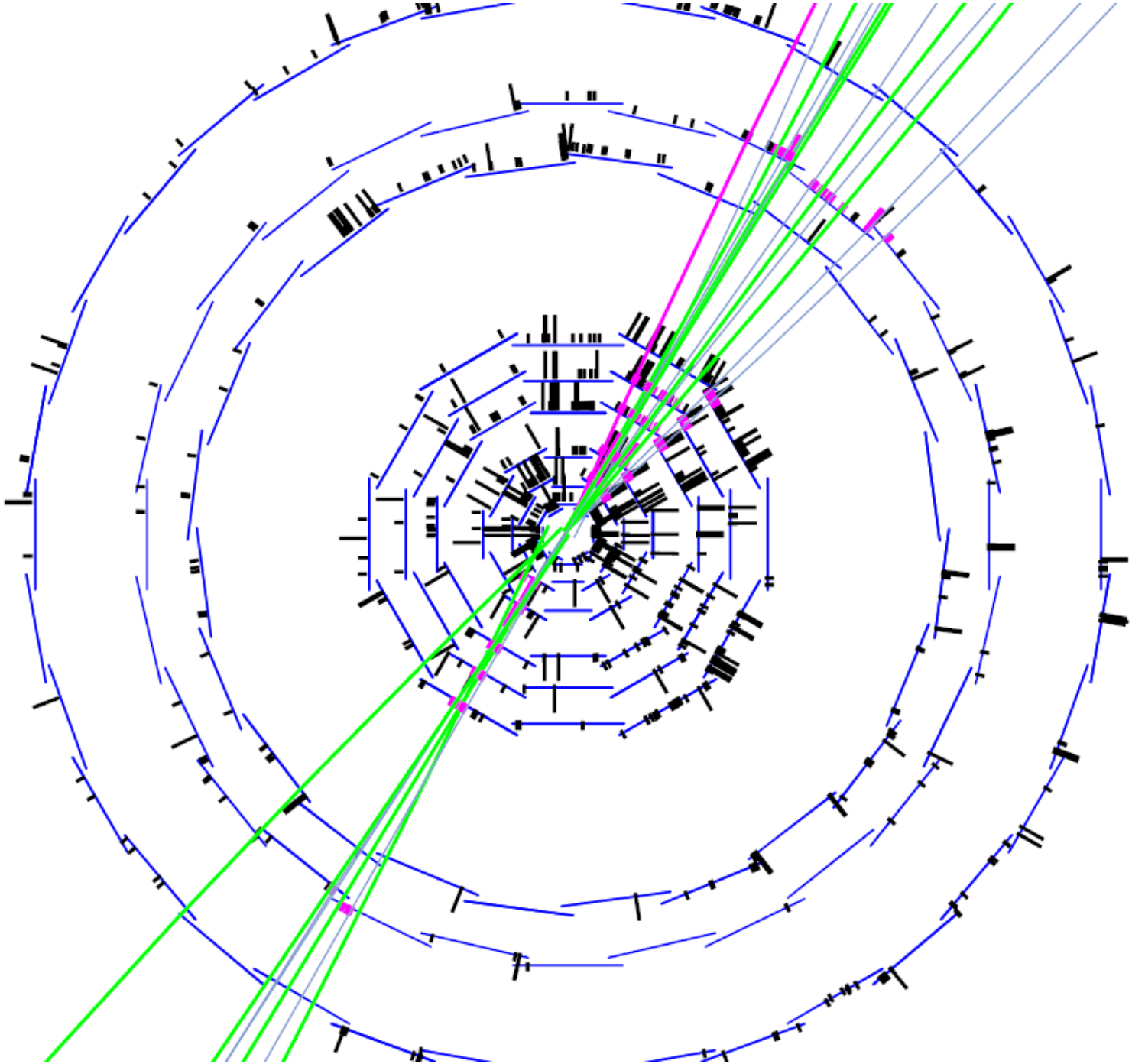


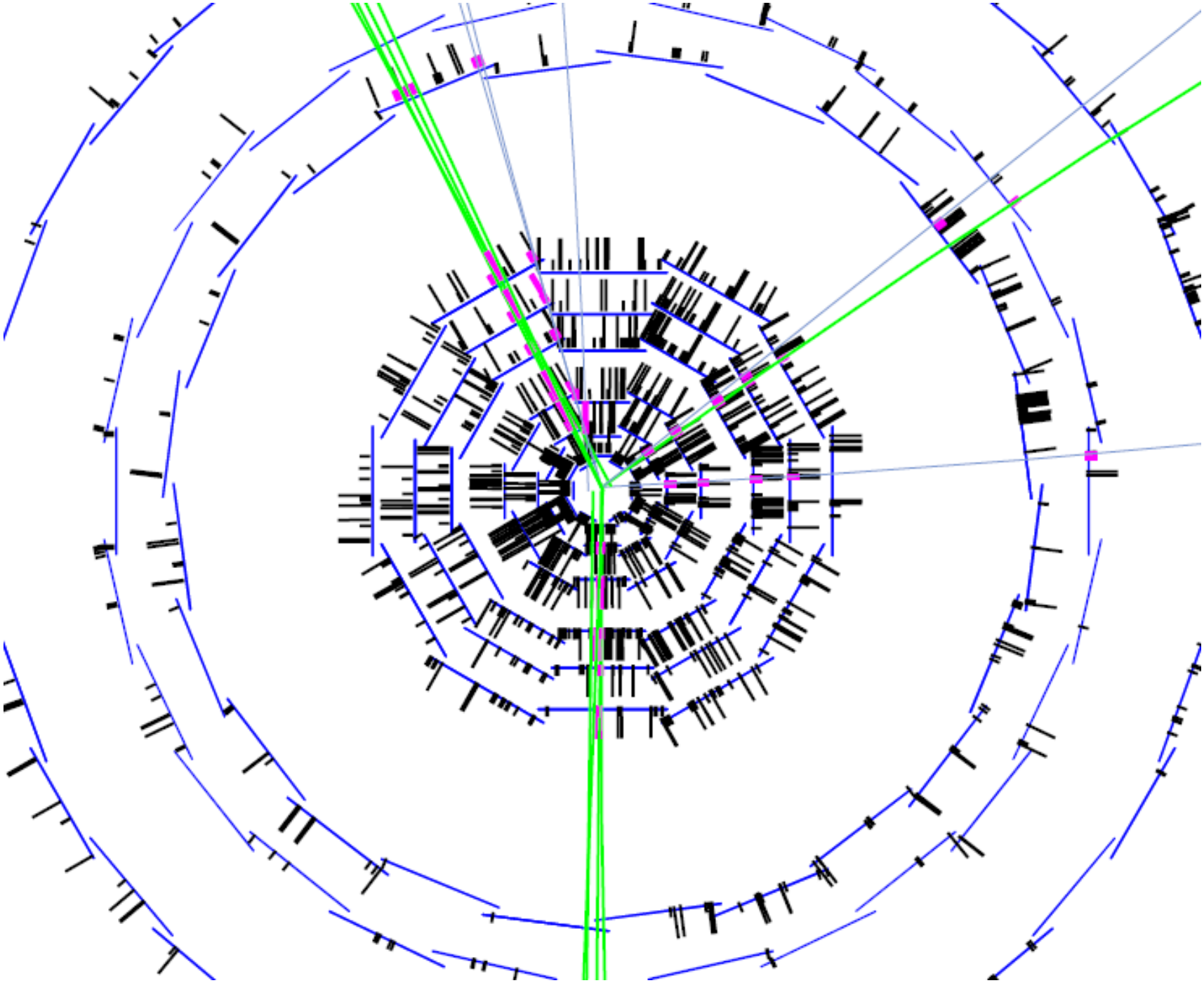


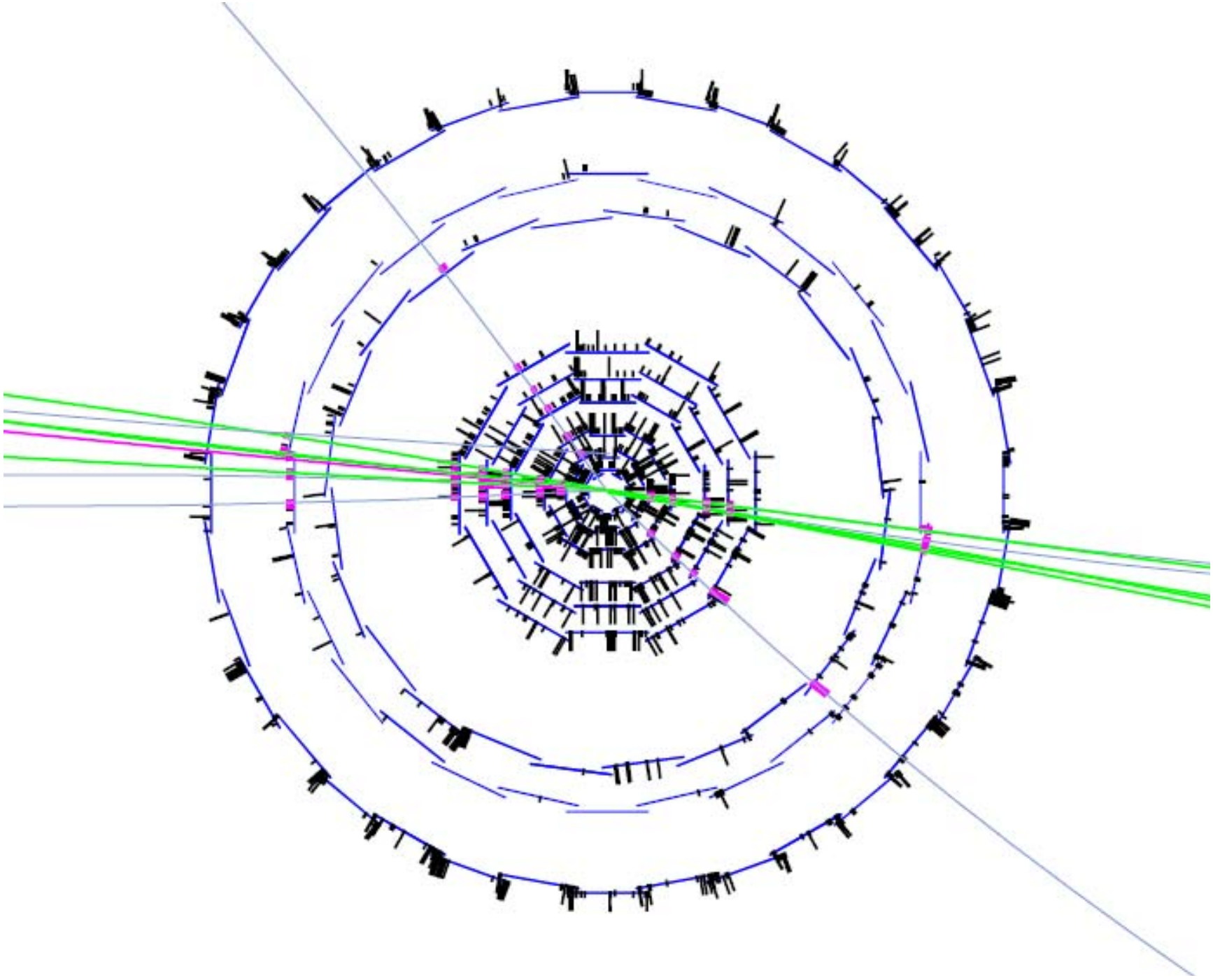


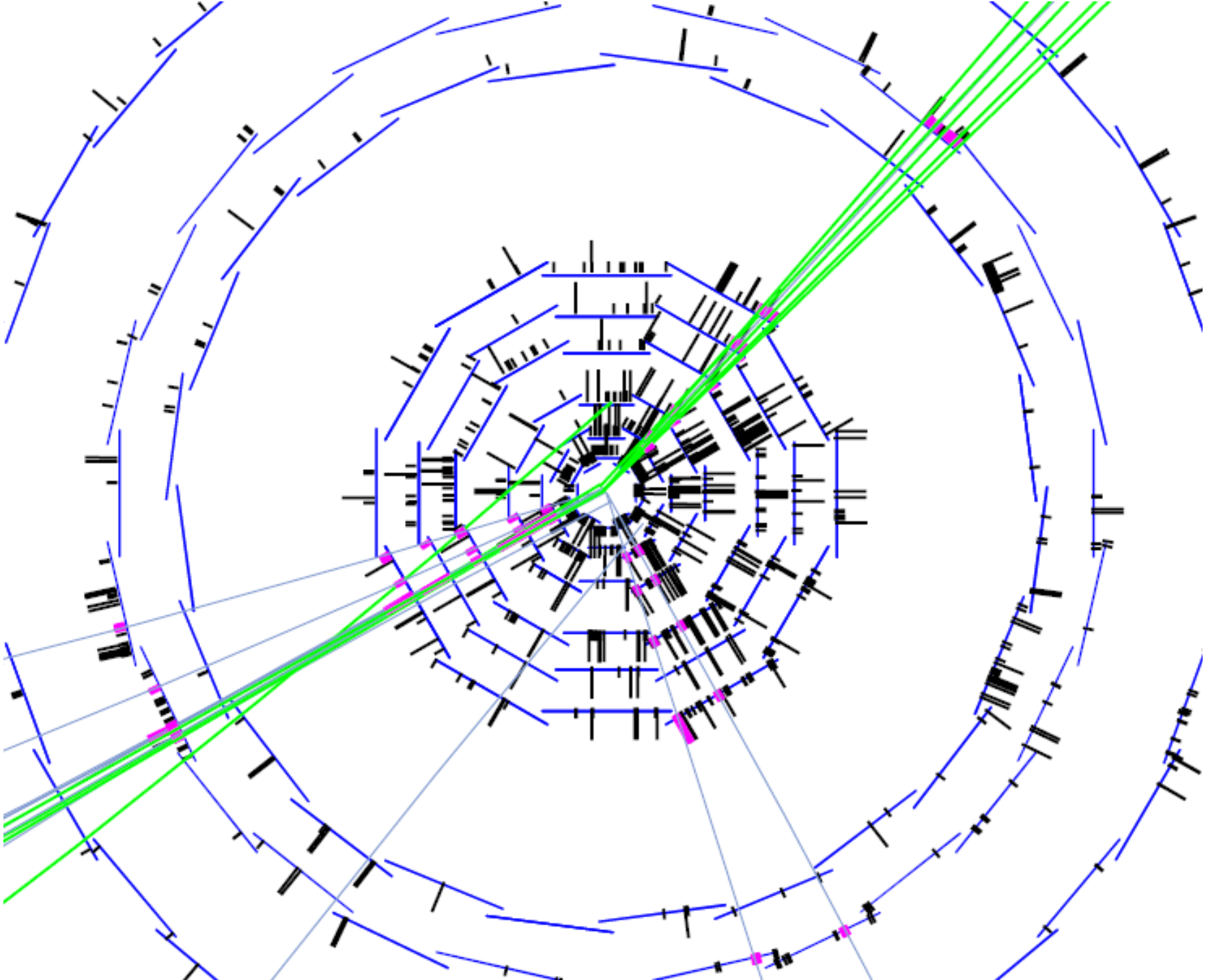


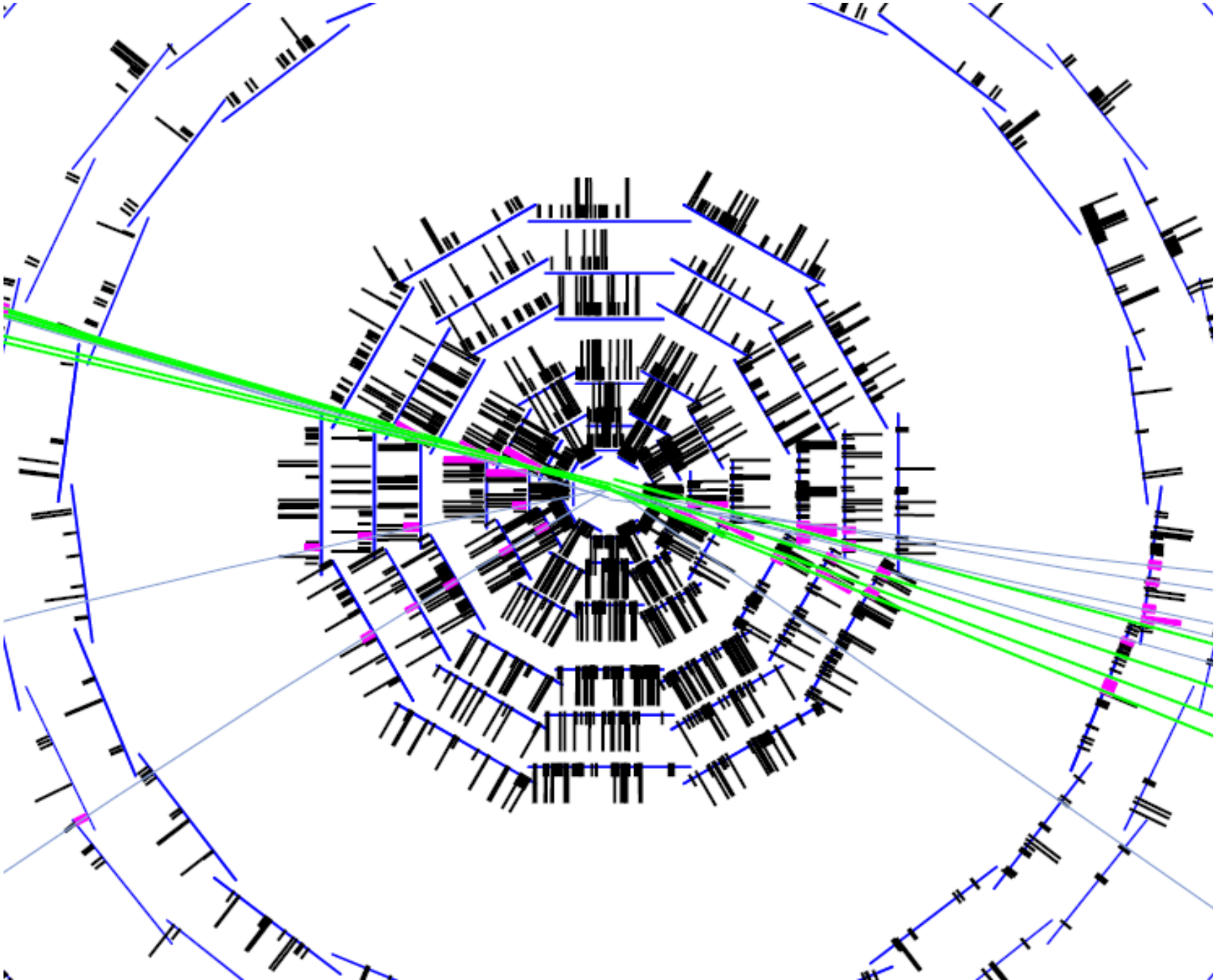




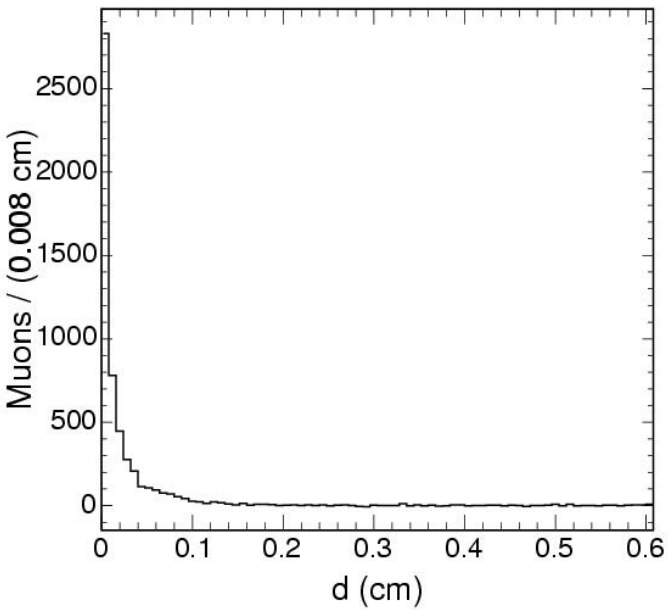
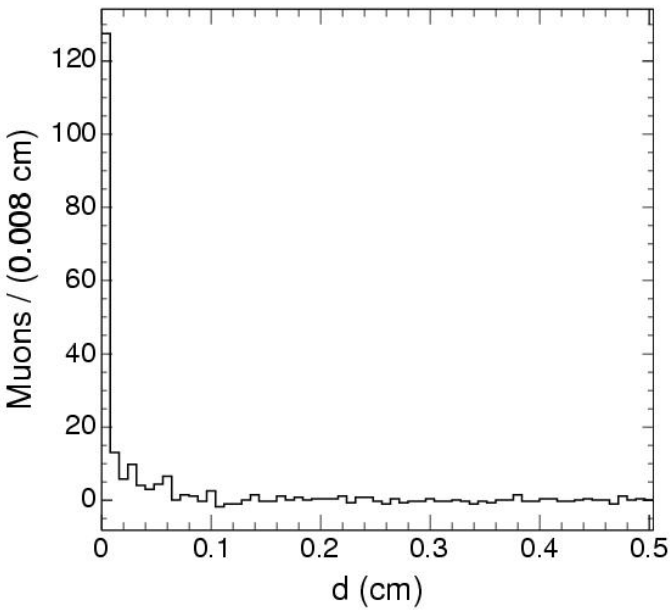








1. Impact parameter distribution of additional muons in QCD events for (left) one additional muon and (right) two additional muons.
   There are no cases with 3 additional muons in QCD events.

QCD events	
	
One additional muon	Two additional muons

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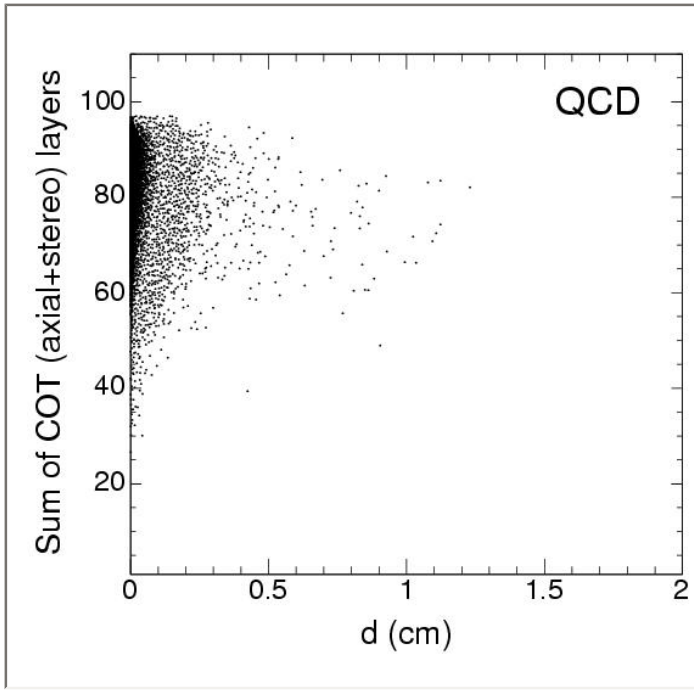
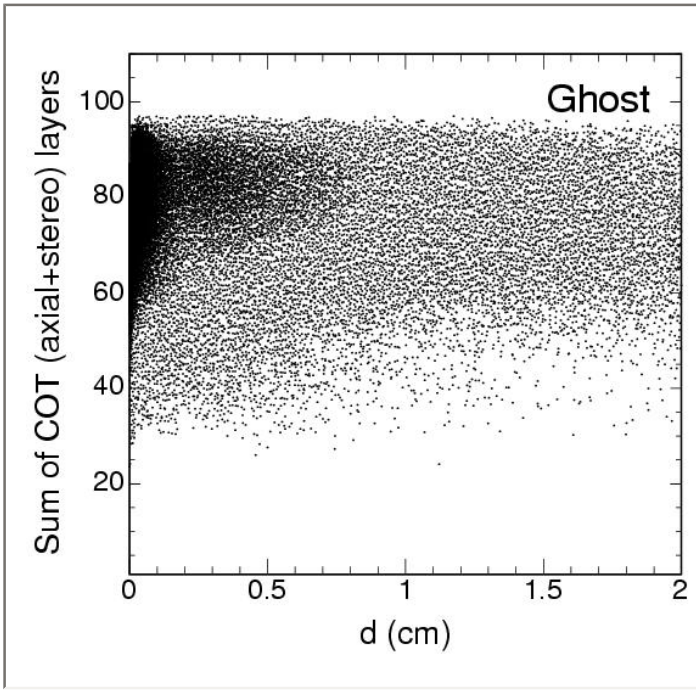
1. Sum of associated COT layers (axial+stereo) versus the impact parameter for trigger muons in QCD (left) and ghost (right) events.



QCD events



Ghost events

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Info related to the dataset used for the analysis

1. For Stntuple users, all they need is:

   dataset jbmm from this web page:
   http://www-cdf.fnal.gov/tiki/tiki-index.php?page=Stntuple.Datasets.HighPtData

2. Trigger path used:

   L1: **L1_TWO_CMU1.5_PT1.5** (this basically feeds all central dimuon triggers)

   L2: **L2_CMUP1.5_PT3_&_CMU1.5_PT1.5** (later DPS) (requires one of the muons to be p_T > 3 and CMUP)

   L3: **L3_BBAR_TWO_CMUP3** (two CMUP muons p_T > 3 GeV, Mass($\mu\mu$)>5 GeV)

   Path: **BBBAR_TWO_CMUP3** (later BBBAR_TWO_CMUP3_DPS)

   Dataset: **B_DIMUON**

   The trigger was originally unprescaled. Beginning with table PHYSICS_3_07_v1, the trigger had a dynamic prescale at L2.

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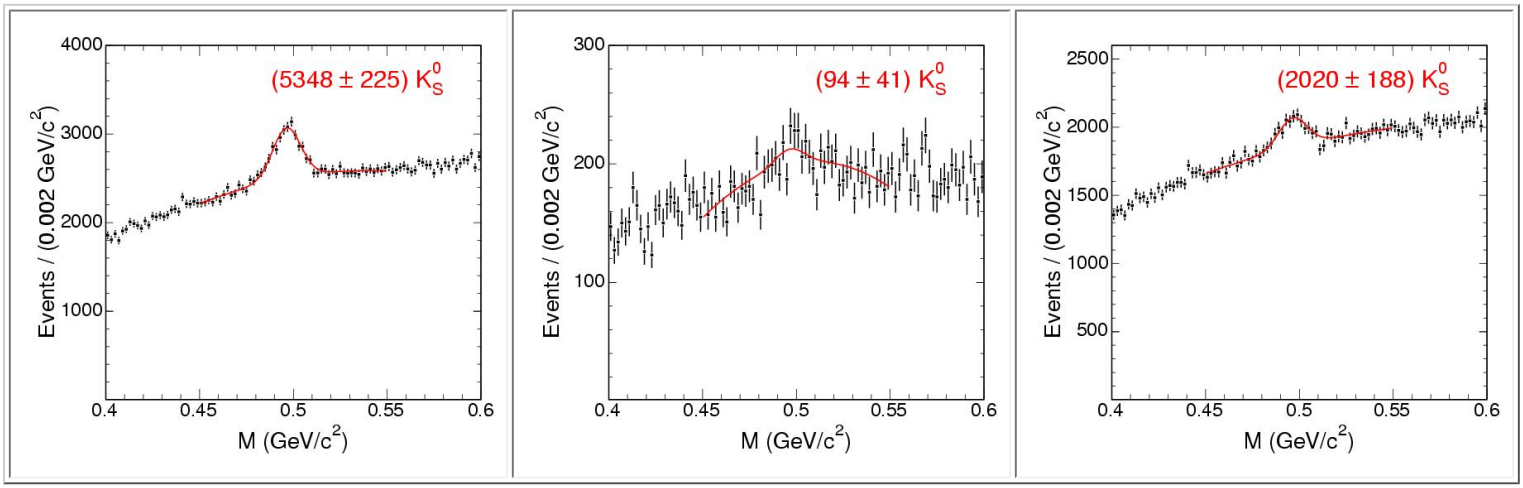
Search for K^0_S

1. Invariant mass distribution of $K^0_S \to \pi^+\pi^-$ candidates.

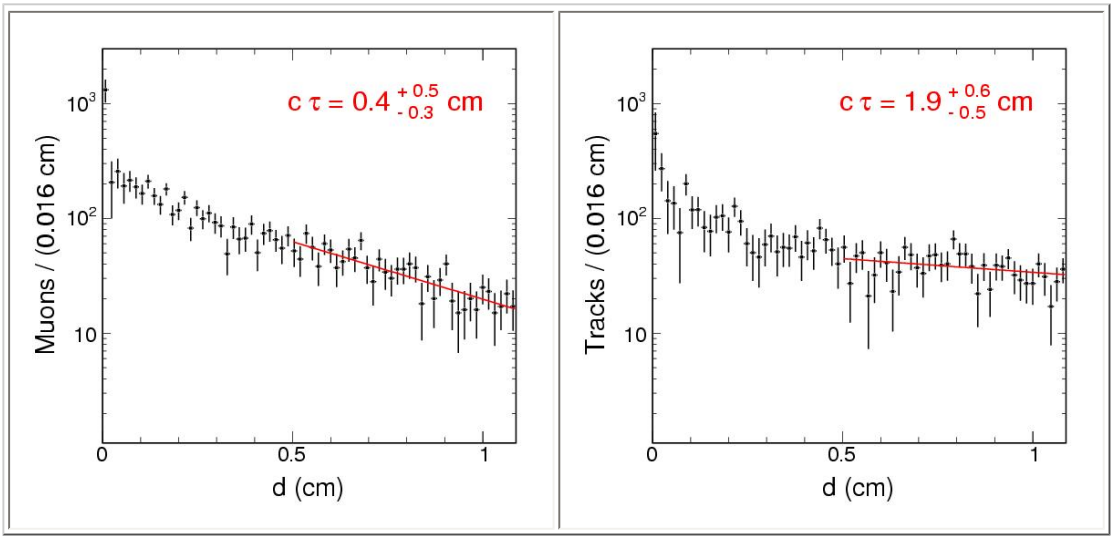
   Following Todd's suggestion, we have searched the dimuon dataset for $K^0_S \to \pi^+\pi^-$ decays by combining initial muons with all tracks with $p_T > 0.5$ GeV/c that are in a cone of 40^0 around the direction of an initial muon. An identified K^0_S signal is obviously due to the punchthrough of a pion track that mimics a muon signal. We vertex constrain the muon-track system and reject combinations with a χ^2/DOF larger than 10.
   We do observe a signal of 5348 K^0_S (left plot). If we use tracks with $p_T > 2$ GeV/c, the signal is halved (2549±134) K^0_S. Therefore, one can safely assume that there are not many K^0_S mesons with tracks with $p_T < 0.5$ GeV/c. This also puts an upper limit to the number of hyperons that populate our sample because of the punchthrough of the hyperon decay prongs. Hyperons are more massive and less abundant than K^0_S.

   The middle plot shows the number of K^0_S in events that contain at least one additional muon. One sees that only (1.7±0.8)% of the K^0_S survives this requirement. Again, only (0.9±0.1)% of the Y mesons in our sample survives the additional lepton request. This strongly supports our argument that the request of additional muons suppresses the contribution of standard QCD events acquired with muons due to in-flight-decays, punchthrough, or secondary interactions. It also refutes Pasha's alleged statement that if one has a muon presumably due to punchthrough, the probability of finding an additional muon is 50%.
   The last plot shows the number of K^0_S candidate in events in which both initial muons pass the loose SVX selection.

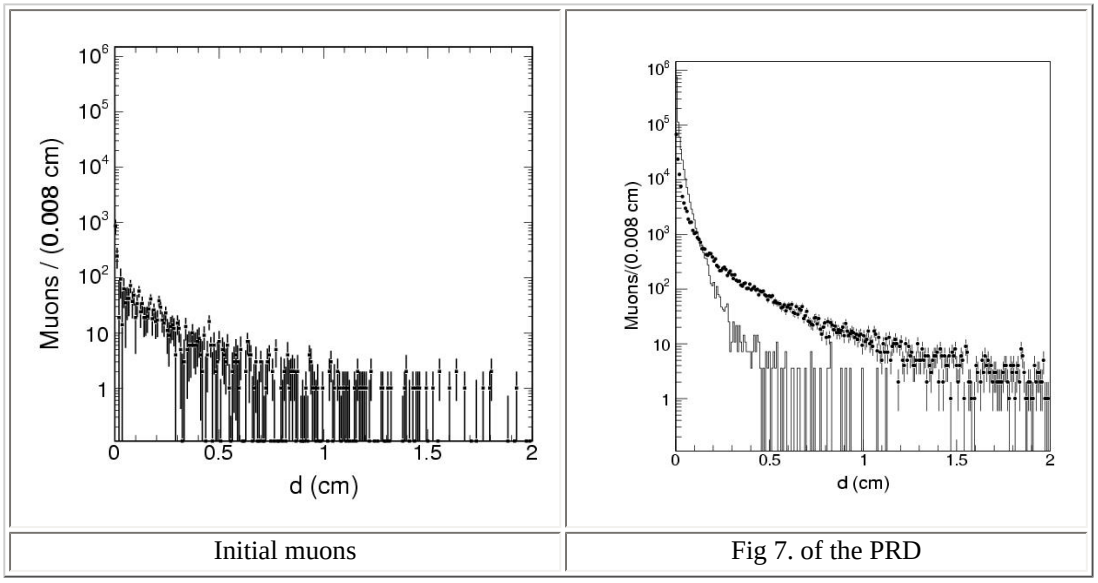


2. The impact parameter distributions of the (left) muon and (right) track of the $K^0_S \to \pi^+\pi^-$ candidates shown above are very interesting. The combinatorial background to the K^0_S signal has been removed with a sideband subtraction method.

   The solid lines represent fits to the distributions with an exponential function. The impact parameter of the initial muon is sculpted by the trigger, and the fit returns a lifetime comparable to that of initial muons in ghost events. In contrast, when using the impact parameter of the additional tracks, the fit returns a lifetime consistent with the PDG and much larger than that of additional muons in ghost events. Searching for K^0_S using tracks with $p_T > 2$GeV/c, we have verified that the impact parameter of these tracks also yields the correct K^0_S lifetime. This is of great support to our conclusion that a fraction of ghost events arise from the decay of a particle with a lifetime never observed before.



3. Impact parameter distribution of the initial muon of K^0_S candidates. The distribution is side-band subtracted. Both initial muons are requested to pass the loose SVX requirements. For comparison we show the impact parameter distributions of muons passing the loose SVX requirements and contributed by ghost and QCD events (Fig. 7 of the PRD).



Initial muons	Fig 7. of the PRD

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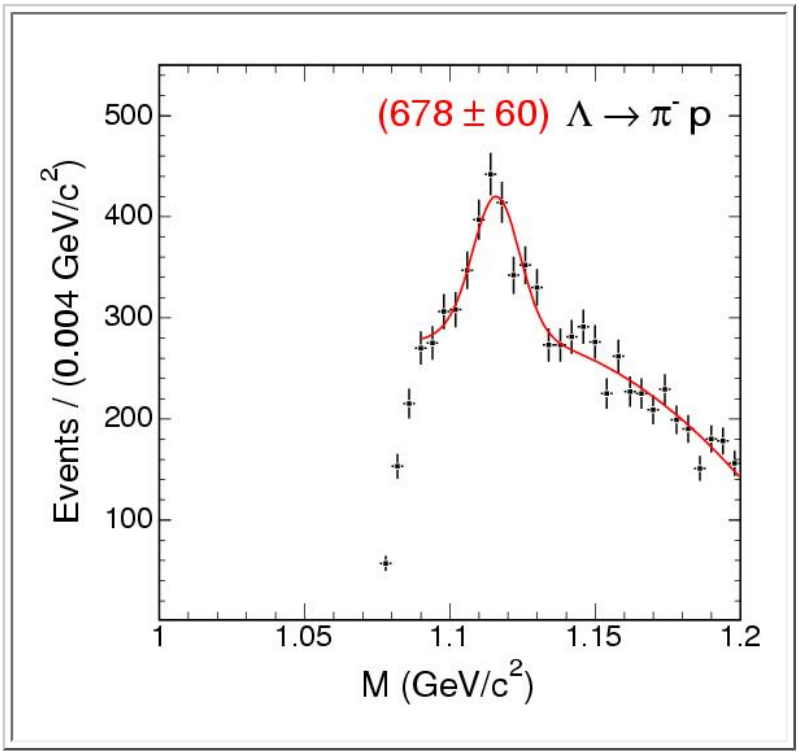
Search for &Lambda → p π-

1. Invariant mass distribution of $\Lambda \rightarrow p\,\pi^-$ candidates.
   Similar to the study performed for K^0_S and described here, we have searched the dimuon dataset for $\Lambda \rightarrow p\,\pi^-$ decays by combining initial muons with all tracks with $p_T > 0.5$ GeV/c that are in a cone of 40^0 around the direction of an initial muon. An identified Λ signal is obviously due to the punchthrough of a pion or a proton track that mimics a muon signal. We vertex constrain the muon-track system and reject combinations with a χ^2/DOF larger than 10. We assign the proton or pion mass to the two tracks according to the charge of the muon.
   After requesting that the muon-track pair has $L_{xy} > 2$ mm we observe a signal of 678±60 Λs as shown in the following plot.



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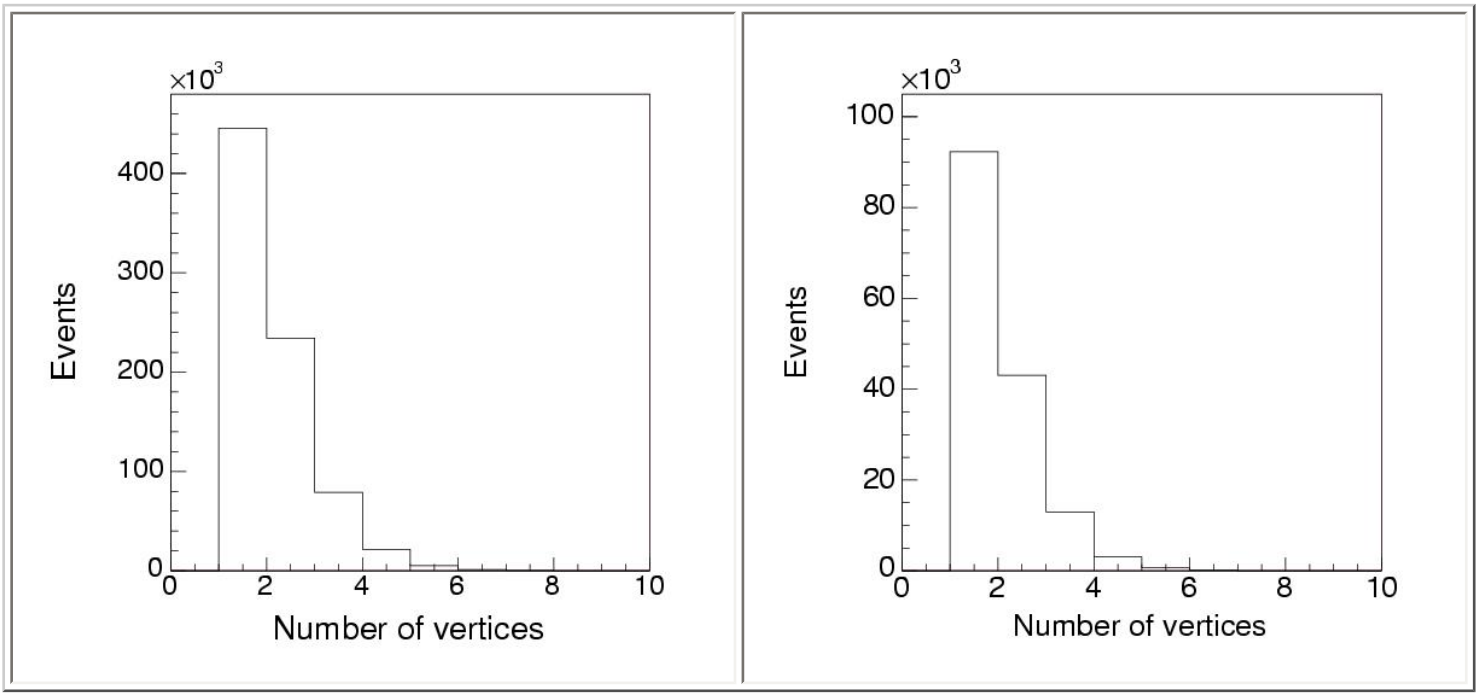
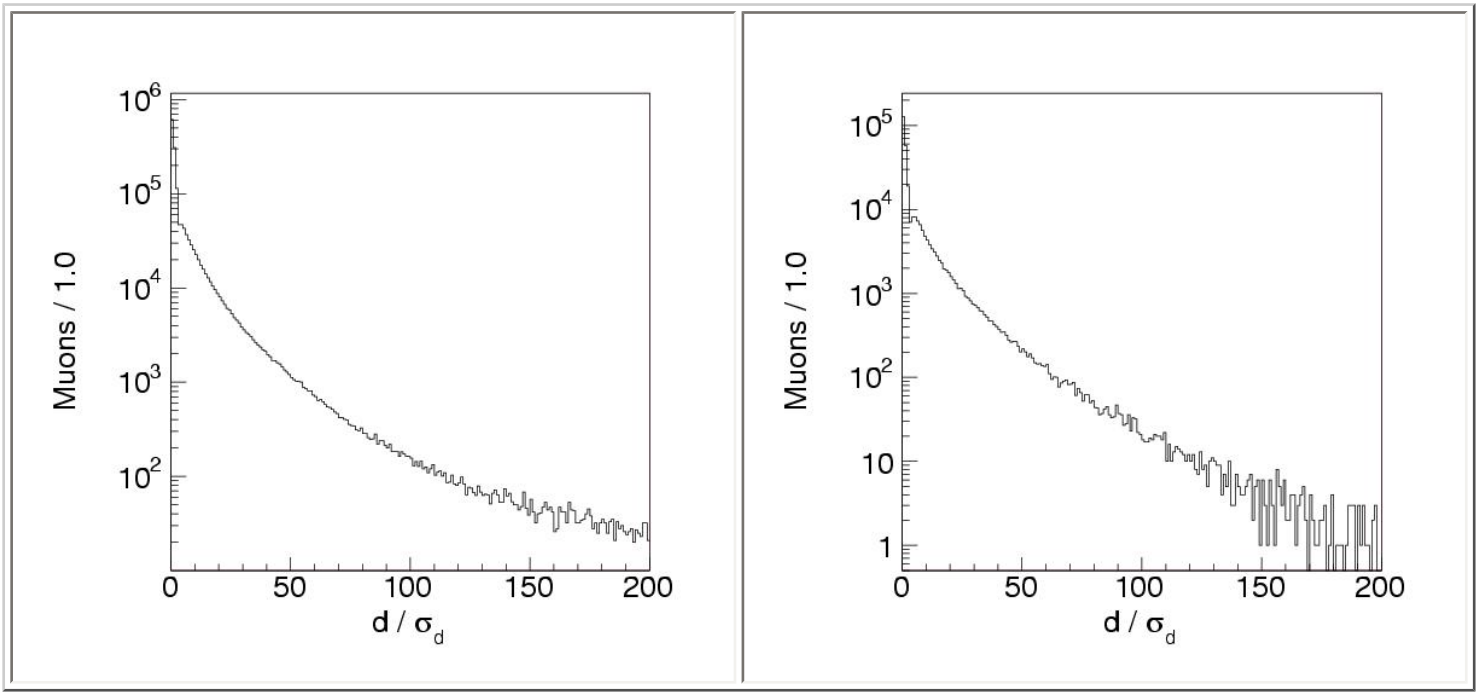
Most requested plots

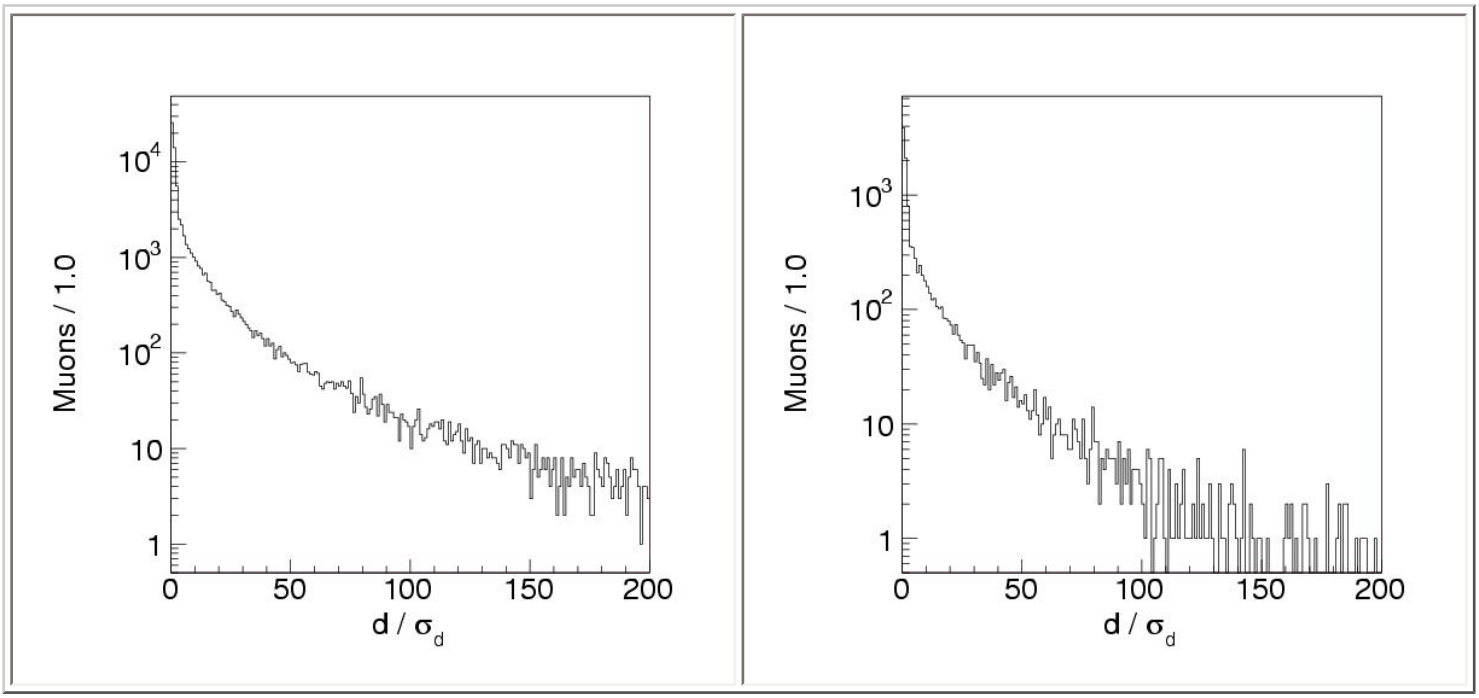
1. Distributions of the number of primary vertices for (left) all events and (right) QCD events.



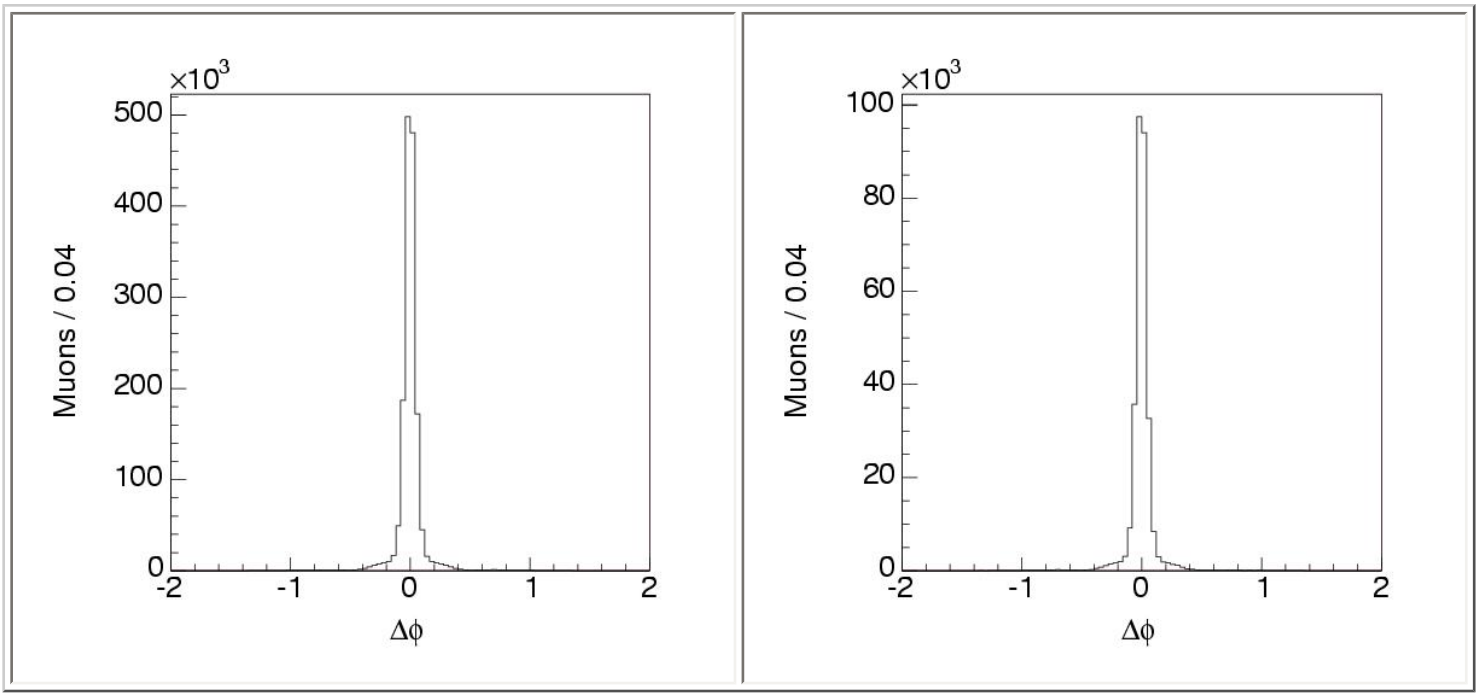
2. Distributions of the impact parameter significance of the initial muons in (left) all events and (right) QCD events.



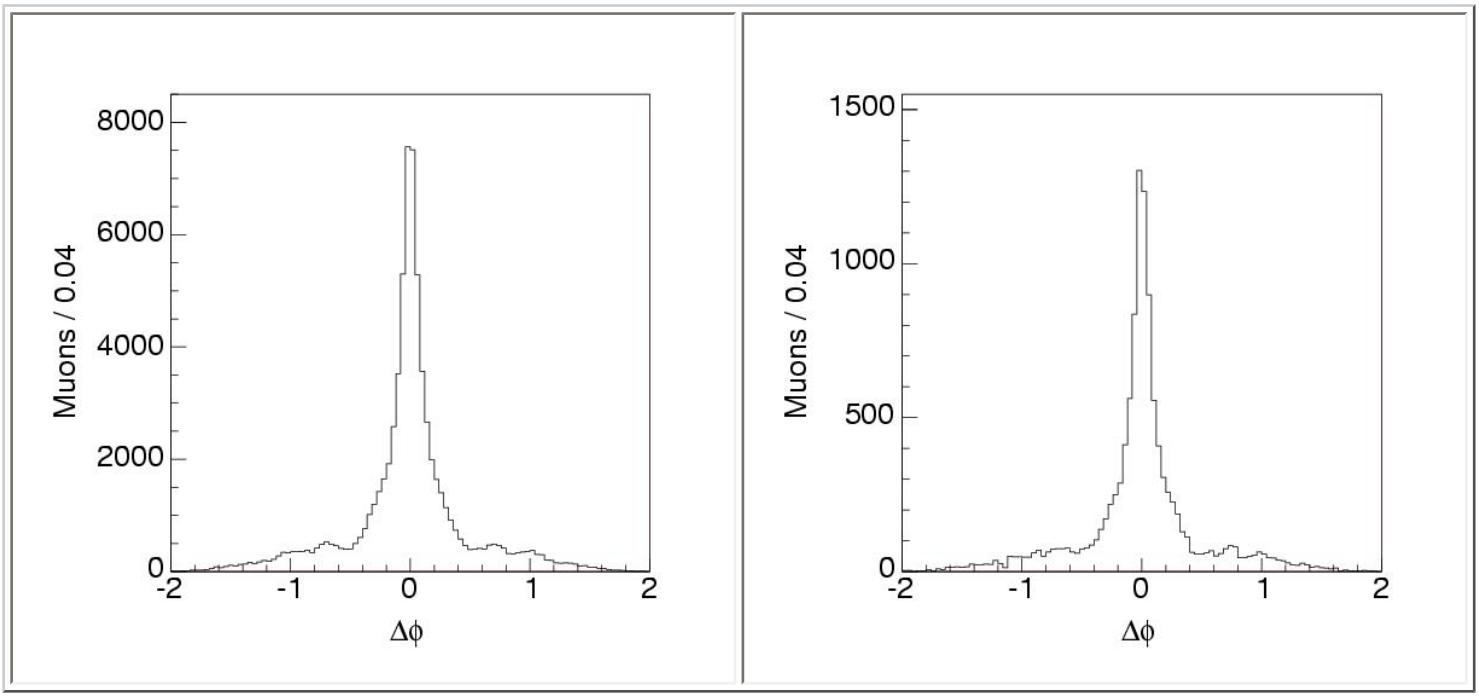
3. Distributions of the impact parameter significance of the additional muons in (left) all events and (right) QCD events.



4. Distributions of the δφ match between the muon stub and track for initial muons in (left) all events and (right) QCD events.



5. Distributions of the δφ match between the muon stub and track for additional muons in (left) all events and (right) QCD events.



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